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TRAINING EFFECTS AND CONCEPT DEVELOPMENT: A STUDY OF THE CONSERVATION OF CONTINUOUS QUANTITY IN CHILDREN

by

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ABSTRACT

The purpose of this study was to investigate children's perceptions, conceptions and generalizations regarding the conservation of continuous quantities and the effects of training on the acquisition of this concept. Piaget's classical pretest of conservation of continuous quantity was administered to a stratified random sample of one hundred and twenty grade one subjects who were subsequently classified according to their knowledge of the conservation principle.

Partial conservers and non-conservers were randomly assigned to experimental and control groups. The experimental group was further sub-divided into groups of ten subjects each. The experimental groups participated in a short training session while the control group received no training. After the training session (or an equal interval in the case of the control group) each subject was retested with the classical pretest. After a two to three week interval, the subjects were given a second posttest designed to assess their ability to retain the concept and their ability to transfer it to a new situation.

The major hypothesis for this study was that learning could take place if certain crucial aspects of the conservation principle were presented to the subjects in a manner in which they could understand. The crucial variables were hypothesized to be: an understanding a fluid retains its identity during transformation, an understanding of the compensatory relationships between height and width, and lastly, an insight into the principle of reversibility.

The major findings of the study were as follows:

1. The training procedures were highly successful and resulted in helping a significant number of non-conservers and partial conservers acquire an understanding of the conservation principle.

2. With the exception of one subject, all the members of the experimental group were able to retain the learning they had acquired over a two to three week period and were also able to transfer their knowledge to a new situation despite an extinction suggestion by the experimenter.

3. No significant changes took place in the control group's understanding of the conservation principle during the time the experiment was in progress.

A number of implications for educational practice are presented with several suggestions for further research in this area.

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CHAPTER I

THE PROBLEM, ITS NATURE AND SIGNIFICANCE

I. INTRODUCTION

This study is concerned with children's perceptions, conceptions and generalizations regarding the conservation of continuous quantities and the effects of training on the acquisition of this concept. Piaget and his colleagues have conducted a number of investigations (Piaget and Inhelder, 1941; Piaget, 1952, 1957) which have indicated that children below the ages of approximately seven or eight years of age do not understand that an amount of substance remains invariant despite transformations in shape or arrangement.

The understanding that substances remain invariant despite alterations in form is referred to as the concept of conservation. When applied to fluid quantities which are not readily discernible as separate entities, the concept is termed the concept of conservation of continuous quantities. A child who has not developed the concept usually thinks that when a given quantity of fluid is poured from one container into another which is taller and narrower, the quantity increases with the rise in the level of the fluid.

Many studies concerning children's conservation concepts have been conducted by investigators who have concerned themselves with examining their subjects' abilities to conserve such quantities as: mass, continuous and discontinuous quantity, weight, area, length,

number and volume. A number of these studies are listed in the bibliography of this report. Their existence attests to the fact that Piaget's initial investigations have given rise to numerous studies by other researchers and subsequently, to a substantial amount of literature. Most of the investigations prior to 1963 have been reviewed and discussed by Flavell (1963) and Wallach (1963).

Several of the earlier studies have been of an exploratory nature and concentrated on identifying the stages in the development of the concept and the ages at which these stages occur. More recently, studies have centred on attempts to determine the effect of training or experience on the acquisition of the concept. Relatively few of the latter have achieved conclusive results and have been criticised on at least two counts (Flavell 1963 ; Sigel 1964). One, it has been suggested that the lack of success may be attributable to the fact that either the investigators did not employ sufficiently long periods of training, or two, they did not ascertain with sufficient accuracy the necessary procedures which would lead the child to an understanding of the concept. Flavell (1963) has interpreted this apparent inability to develop the concept experimentally as conferring "a degree of back-hand validity" to Piaget's theory of concept formation. Whether these levels of mental development must develop in some as yet undetermined manner as the child matures, whether the development can be aided or accelerated by appropriate teaching techniques, or whether such techniques can even be devised has not been conclusively answered by any of

the studies to date. However, recent studies by Bruner (1966), Sawada (1966), Lefrancois (1966) and others have achieved sufficient degrees of success to at least throw suspicion on some of Piaget's claims and would indicate that either his theory is wrong or his age-stage relationships are incorrect, or both.

The purpose of this study was to investigate the acquisition of the concept of conservation of continuous quantity and to attempt to develop the concept experimentally. Previous studies have failed to isolate the specific cognitive abilities children need in order to understand the principle of conservation. It was hoped that the results of this investigation would provide support for the theory that the crucial variables in the acquisition of the concept of the conservation of continuous quantity are: the understanding that a fluid retains its identity during transformations, an understanding of the compensatory relationship of height and width, and lastly, a knowledge of the principle of reversibility.

Other investigators have achieved limited successes in their attempts to teach children conservation concepts. However, by using a new approach and avoiding the mistakes made by previous researchers, it was hoped that the present study would show that children can be taught conservation concepts earlier and more efficiently than had previously been the case.

In addition, answers to the following questions were sought: What processes are involved in the development of this concept? Can

these processes be explained satisfactorily by Piaget's theory? Can these processes be developed in children earlier than is normally the case according to Piaget?

II. THE HYPOTHESES

The major hypothesis for this study was that conservation would result when children who had been classified as non-conservers were provided with experiences designed to lead them to an understanding of conservation. Support for this hypothesis lies in the fact that Piaget (1964) has stated that learning is possible if more complex structures are built upon simpler structures. He also points out that concept development is not merely a result of external reinforcement.

From Piaget's original experiments and subsequent replications, we know that children who do not conserve first centre on one or two criterial attributes of the problem but cannot combine them into a system to explain conservation. In the conservation of continuous quantity for example, children may be able to recognize that a transfer from A to B may be reversed by a transfer from B to A, yet they will still not conserve. Similarly, some children center their attention on either the level of the water or the size of the container and cannot coordinate the relationship between the change in the water level and the change in the height and width of the containers. Apparently, it is only when these separate aspects of the problem

are combined into an all-encompassing thought pattern that conservation appears.

Bruner (1966) and his colleagues suggest that the crucial aspects of the ability to conserve centre about the child's ability to perceive that the identity of the fluid being poured does not alter. That is, if the child does not appreciate that the fluid poured from A to B is the <u>same</u> fluid that was originally in A then conservation is not likely to occur.

In view of the above, it was theorized that if a series of experiences were designed which would help the child realize that the identity of the fluid remains unchanged over transformations, shield him from his initial perceptions of the rise or fall of the levels of the fluids, and aid in his understanding of the compensatory nature of the relationships of height and width in the sets of jars, then the acquisition of the concept of conservation might very well be accelerated.

The research hypotheses listed below refer to various groups which are fully described in chapter three of this report.

<u>Hypothesis 1</u>. The number of non-conservers who change to conservers as a result of the treatment is not significant.

<u>Hypothesis 2</u>. The number of partial conservers who change to conservers as a result of the treatment is not significant.

<u>Hypothesis 3</u>. The number of non-conservers who change to partial conservers as a result of the treatment is not significant.

Hypothesis 4. There is no significant change in the number of subjects in the non-conserver control group at the end of the experiment.

Hypothesis 5. There is no significant change in the number of subjects in the partial conserver control group at the end of the experiment.

Hypothesis 6. There is no significant change in the number of subjects in the conserver group at the end of the experiment.

Hypothesis 7. The number of non-conservers reclassified as conservers after the treatment who, over a two to three week period, change from giving conservation responses is not significant.

Hypothesis 8. The number of partial conservers reclassified as conservers after the treatment who, over a two to three week period, change from giving conservation responses is not significant.

III. LIMITATIONS

This study was limited in respect to the aspects listed below.

1. The sample was limited to urban children in the first grade.
2. The intelligence range of the sample was confined within a specified normal range.
3. Only one concept, that of conservation of continuous quantity, was studied.
4. The training procedures used in the study were designed to accelerate only this one concept.

5. Subjects whose native language was not English were excluded from the study.

6. Subjects whose school records indicated evidence of uncorrected visual problems were excluded from the study.

7. The subjects were classified as non-conservers, partial conservers and conservers on the basis of their performance on Piaget's classical test of conservation of continuous quantity.

IV. SIGNIFICANCE

The significance of this study centres upon three related aspects: (1) the significance of the concept of conservation for education, (2) the possibility of developing this concept experimentally, and (3) the degree to which Piaget's theory can be used to explain the acquisition of the concept.

The importance of the concept of conservation for education is often overlooked, but, as Piaget (1960) has pointed out, every notion, irrespective of whether it is scientific or merely common sense, presupposes a set of principles regarding conservation. That is, no system of thought patterns can be developed unless there is a permanence among the elements. Even in the area of perception, the understanding of the permanence of an object depends upon an understanding of conservation.

Piaget (1952) states that,

> whether it be a matter of continuous or discontinuous quantities . . . or sets of numbers conceived by thought, . . . in each and every case the conservation of something is postulated as a necessary condition for any mathematical understanding. (p. 2-3)

It may also be argued that an understanding of the concept of conservation is a necessary condition for all reasoning. Since the schools are trying to develop children's abilities to reason, then it should be readily apparent that an understanding of the conservation concept is of fundamental importance to educators.

A substantial body of evidence now exists which indicates that conservation concepts are related to several areas of the school curriculum. Since conservation is fundamental to measurements of mass, length, area, weight and volume, it is obvious that a knowledge of this concept has important practical applications to such school subjects as mathematics and science. Research by Rawson (1965) has shown that cognitive growth including the development of an understanding of conservation is related to reading comprehension. Lansing (1966) claims that a child's ability to think in terms of concrete operations (a stage which is characterized by an ability to conserve) has an important influence on the child's art work. Pflederer (1964) found that an ability to conserve was related to children's performance in certain musical tasks. Almy (1966) reports that the ability to conserve is related to school achievement in general and to the areas of beginning reading and

numerical concepts in particular. In addition, Sigel (1966) claims that an understanding of conservation is one of the cognitive acquisitions necessary for understanding the social sciences which are taught to children in social studies courses.

The desirability of teaching conservation of continuous quantity before any other type of conservation stems from the fact that Piaget's investigations have shown that these concepts develop in a sequential pattern <u>beginning with</u> the conservation of continuous quantity. On the basis of these facts, it seems profitable to investigate further the development of this concept.

The question of whether or not the concept can be developed experimentally also has great relevance both for the field of education and for child psychology. Piaget postulates that it is difficult to teach a child this concept until he has reached a certain state of mental maturity. If it is possible to help children develop certain concepts, it is imperative that educators find out what procedures may be utilized to aid students in their acquisition of specific concepts.

Finally, this study is important in that its findings may be used to supply further evidence to be applied to the validation of Piaget's theories.

V. DEFINITIONS OF TERMS

The Concept of Conservation. The understanding that the amount of a substance remains invariant despite transformations in shape and arrangement provided nothing has been added or subtracted from the original amount.

The Concept of Conservation of Continuous Quantity. The understanding of the principle of conservation as applied to fluid quantities.

Conserver. A subject who scores correctly on both sections of Piaget's classical test of conservation of continuous quantity.

Partial Conserver. A subject who scores correctly on one but not both sections of Piaget's classical test of conservation of continuous quantity.

Non-conserver. A subject who fails to score correctly on either section of Piaget's classical test of conservation for continuous quantity.

VI. THE EXPERIMENTAL SETTING

The experimental design and statistical procedures used for analyses are fully described in Chapter III. A brief summary of the setting of the experiment is given here for purposes of clarification and continuity.

The population from which the sample was drawn consisted of the total grade one enrollments of two elementary schools of the Edmonton Public School System. The stratified random sample involved in the study was comprised of one hundred and twenty subjects. Twenty of these subjects took part in the pilot study while the remaining hundred were involved in the main part of the experiment. The stratification criteria included the following parameters.

1. Intelligence. The intelligence measures of the population as assessed by the Detroit Beginners Test were noted and those subjects whose scores (normalized for Edmonton) did not fall within the range of 95 to 115 were excluded from the study.

2. English as the native language. Subjects who came from homes where English was not the native language (as indicated by the school records) were similarly excluded from the study.

3. Defective vision. The cumulative record folder of each subject was examined and children who had uncorrected vision problems as assessed by the school medical authorities were also excluded.

Each subject in the sample was individually tested and classified as either a non-conserver, a partial conserver or a conserver. Piaget's classical test of conservation of continuous quantity was used for this purpose. The non-conservers and partial conservers were randomly divided into two equal groups; an experimental group (N = 40) and a control group (N = 40).

The subjects in the experimental group were randomly combined

into four subgroups of ten subjects each with the non-conservers and partial conservers represented in each group in approximately the ratio of 3:1. Each subgroup participated in a similar, structured learning experience designed to aid in the acquisition of the concept of conservation of continuous quantity.

The learning experience was developed by the author and involved procedures designed to (1) help the children centre upon the identity of a fluid which was transformed, (2) shield them from their initial perceptions of the situation, (3) help them understand the compensatory relationship between the dimensions of the containers which were used in the experiment, and (4) given them an opportunity to express their thoughts concerning the problem in a symbolic mode of thought.

Immediately after the training session in the case of the experimental group, or, after an equivalent interval of time in the case of the control group, a posttest was given to each subject in these two groups. Piaget's classical test of conservation of continuous quantity was the test used and each subject was reclassified according to his knowledge of conservation. The original group of conservers and the experimental subjects were retested after a two or three week interval had elapsed. The second posttest was designed by the author to assess the experimental subjects' ability to retain the benefits (if any) which they had derived from the training session over a certain period of time. It also attempted to ascertain whether

these subjects could transfer this knowledge to a new situation using different fluid quantities. The second posttest was also administered to the subjects who had initially been classified as conservers.

VII. THE OUTLINE OF THE REPORT

The present chapter introduces the problem and serves as a preview of the study. Chapter II contains a review of the pertinent literature while Chapter III describes in detail each aspect of the experimental design, testing procedures and the statistical analyses used to test the hypotheses. Chapter IV contains the results of the data analyses and a description of some observations noted during the testing program. The final chapter, Chapter V, includes a summary of the study, reports the conclusions and implications and presents several suggestions for further research.

CHAPTER II

A REVIEW OF THE RELATED LITERATURE

I. INTRODUCTION

The impetus for a great deal of the research reported here originated with the investigations Piaget and his colleagues conducted as early as 1921. Since then, there have been numerous studies by other researchers in which they have attempted to: validate Piaget's findings, replicate his experiments, find the ages and developmental stages when certain concepts develop in children of various cultures, and more recently, induce certain concepts experimentally.

This chapter contains a review of Piaget's research on conservation and a discussion of some of the theoretical explanations for the development of this concept in children. Studies in which attempts have been made to develop conservation concepts experimentally are also reviewed. Reviews of research dealing with aspects of children's concepts other than conservation may be found in Flavell (1963) and Wallach (1963).

II. THE RESEARCH OF PIAGET

One of the earliest reports of Piaget's investigations concerning children's notions of quantity appeared in French in 1941

(Piaget and Inhelder, 1941), but it was not until 1952 that a text dealing with the same topic was published in English (Piaget, 1952). In the latter, Piaget describes what has become known as the classical test for the conservation of continuous quantity. While there are minor variations in technique, the basic procedure consists of presenting a subject with two similar containers (beakers) equally full of some fluid quantity such as water. After the subject has agreed that the two containers contain the same amount of liquid, the contents of one container are poured into a new container which is different in size and shape.

The subject is then asked if there is the same amount of liquid in the new container as there is in the remaining original container. If the new vessel is tall and thin, children who do not conserve usually reply that there is more fluid in the latter since the water level rose to a higher level.

The second part of the test begins with two similar containers as above. This time the contents of one are poured into several smaller containers and the conservation question is asked. In this case, non-conservers usually think that several small containers of liquid combine to make more than the original amount.

Piaget has conducted investigations of a similar nature into children's concepts of conservation of quantities such as mass, weight, and volume. In each case he claims to have found a general three stage pattern in the child's conceptual development. First,

there is no conservation; second there is an empirically founded conservation in which the child tentatively hypothesizes conservation for some of the transformations involved in the test but not for all cases; third there is complete conservation in which the child asserts the invariance of the quantity despite any transformation performed upon it.

According to Piaget, his subjects understood the principle of conservation at various ages depending upon the quantity involved. Hence, for conservation of substance, he claims that is subjects were between eight to ten years of age. The ages for mastery of conservation of weight were from ten to twelve and his subjects were older than twelve before they understood conservation of volume (Flavell, 1963, p. 299). There seems to be some confusion in the literature regarding both the age limits Piaget lists for the acquisition of the conservation concept as applied to various substances and the criteria he used in formulating these stages. Piaget himself does not list any ages in his text on number (Piaget, 1952) but does state in other works (Piaget, 1960) that conservation of substance, weight and volume is attained by the ages of seven or eight, nine to ten, and eleven to twelve respectively. These ages are the ones generally accepted by most investigators.

The confusion regarding the criteria used to include subjects in one or another stages of development is a result of the ambiguity of Piaget's reports in which he fails to state what proportion

of his sample had to answer what proportion of items correctly in order to be classed as conservers or non-conservers. Consequently, some investigators have used a 50 percent criterion while others have used a 75 percent level of performance. Piaget has, on at least one occasion, used a 75 percent criterion level in assigning tests to age levels (Piaget, 1951) and his criterion is generally accepted as most appropriate for the delimitation of age-state relationships.

III. THEORETICAL EXPLANATIONS OF CONSERVATION

There are at least two major theories to explain how the concept of conservation is acquired. The first is Piaget's equilibration theory; the second is Bruner's theory concerning children's modes of thought.

Piaget's Theory

Piaget claims that there are four factors which influence or can account for cognitive development: maturation, experience, social transmission, and equilibration or self-regulation. Piaget feels that the first three factors are insufficient to explain cognitive development completely and has theorized that his equilibration model is the most appropriate.

According to the equilibration theory, the subject is active in the act of knowing, consequently, when he is faced with an external disturbance, he reacts in order to compensate and will thus tend towards equilibrium. The latter, defined by active compensation, leads

to reversibility in Piaget's terminology. Operational reversibility is itself defined as a process in an equilibrated system where a transformation in one direction is compensated for by a transformation in the other direction (Piaget, 1964).

The manner in which this theory can be applied to the acquisition of conservation may be made clearer by means of an example. In the conservation of continuous quantity for instance, the development of the concept is believed by Piaget to occur in a three stage sequence. In stage one the subjects attend to what Piaget terms relations of gross quantity.. That is, they centre upon <u>either</u> the water level <u>or</u> the dimensions of the containers but not on both these relationships at once. Hence, these relationships cannot be logically multilied. Multiplication of the relations refers to the act of considering the relationships two or more at a time. In reference to the above example, the ability to multiply the relationships between height and width is postulated as resulting in an understanding of the compensatory nature of these relations and hence, the understanding that what is lost in width (in a tall container) is compensated for by an increase in height.

During the second stage, the child tries to take the two relations into account simultaneously, but without success since he is easily confused by his perceptions of the water level. During this stage the child first realizes the importance of the fact that the containers are not alike and attempts to take their dissimiliarity.

into account. At this stage the child may first focus on the height-width relations and then on the water level or vice versa. At this point, the subject has opposing reactions to the question of whether or not the amount of liquid is conserved, hence, he is (as Piaget would say) in a state of disequilibrium.

In stage three, equilibrium is attained and conservation of the quantity is asserted when the child successfully co-ordinates the relations between height, width and water level.

As Piaget himself points out (Piaget, 1964) this is essentially a probabilistic model to explain the acquisition of conservation. Stage one, centering on one aspect alone, is more probable than stage two where the child may center on two aspects but not at the same time. Finally, stage three is even less probable than either of the other two. Supposedly, the child's growing dissatisfaction with his responses in stages one and two leads him to a stage of equilibrium in which he understands the compensatory relationships between the relations and thus achieves conservation.

Other authors have already pointed out (Lefrancois, 1966), that Piaget's theory may explain the steps in the development of conservation, but it does not explain how the child developed the cognitive structures necessary for this understanding. Too frequently, Piaget's findings have been interpreted as meaning that the ages and stages he has described for certain concepts are fixed and cannot be altered or accelerated. It is doubtful if this is what Piaget has

meant to convey, for while he does state that the logical structures of the mind are not the result of experience cannot be obtained by obtained by external reinforcement (Piaget, 1964) and may be reached only through the process of internal equilibrium, he does not rule out the possibility that the learning of a concept may take place prior to the ages which he has listed. Addressing himself to this question at the recent Cornell Conference, he stated,

> In other words, learning is possible if you base the more complex structure on simpler structures, that is, when there is a natural relationship and development of structures and not simply an external reinforcement. . . . learning is subordinated to development and not vice versa . . . (Piaget, 1964, p. 17).

<u>Bruner's Theory</u>

Bruner has criticised Piaget's approach to child development on several grounds (Bruner, 1959, 1966). Rather than propose a logical model as a means of explanation as Piaget does, Bruner feels that since cognitive growth is a series of psychological events it calls for a psychological explanation. He claims that it is incorrect to assume that a child does not perform a certain act in a certain way at a certain age because the child's act exhibits certain underdeveloped logical structures. Nor is it sufficient to explain cognitive development to say that a certain type of behaviour is typical of a specified age group. He also finds fault with Piaget's equilibration theory "both for its lack of specificity and its circularity of prediction about growth" (Bruner, 1966, p. 4). In addition, he

claims that it is inappropriate to describe growth by describing the stages and states through which it passes.

Bruner is concerned with intellectual growth from the viewpoint of how it is affected by the way man gradually learns to represent his world to himself and others through actions, images, and symbols. Hence, his theory deals with the specific nature of internal representation by these three modes of representation: enactive, ikonic and symbolic. According to his theory, the impetus for learning does not result from an internal disequilibrium in Piaget's sense, but when two systems of representation do not correspond, as for example, when there is a discrepancy between what one sees and how one says it. It is due to this type of conflict, says Bruner, that the child makes revisions in his way of thinking.

In applying this theory to the conservation concept, Bruner attempts to explain its development by postulating that a child may say (symbolic mode) that the quantity of water will remain unchanged if it is poured into another container, but when he sees (enactive mode) the water level rise in the new container, he is deluded at first by his perceptions and disturbed by the contradiction between what he has said would happen and what he perceives to have happened. Bruner claims that it is this type of disequilibrium between modes of thought that leads the child to try to resolve the conflict and hence to an understanding of the concept.

One of the more recent theories for explaining children's

reasoning processes has been proposed by McLaughlin (1963) who has combined elements of both Piaget's logical and Bruner's psychological approach into what he has termed a psycho-logical approach. This theory is based in part on the algebra of classes and proposes that each level in a child's thought process as Piaget has outlined them, can be defined by the number of different classes that the child can distinguish simultaneously. In addition, this theory is closely related to the psychological characteristic of memory span.

McLaughlin claims that a child solving a mental problem must retain a number of items in his mind at the same time and that the number he is capable of retaining increases as the child matures. Hence, each of Piaget's four levels of development may be explained in terms of the number of items the child is capable of retaining at that time. The maximum number of classes needed to solve a problem may be calculated. If the given classes are distinguished by a number N of different attributes, then each class of attributes is defined by the number of 2^N possible combinations of these attributes. McLaughlin hypothesizes that in Piaget's first level of development (sensorimotor intelligence) the child possesses the ability to process only $2^0 = 1$ concept at a time. At level two, (pre-operational intelligence) the child can retain $2^1 = 2$ concepts, at level three, (concrete operations) he can handle $2^2 = 4$ concepts and finally, at level four, (formal operations) he can handle $2^3 = 8$ concepts simultaneously.

Since the attainment of the concept of conservation of

continuous quantity occurs during levels two and three, the application of McLaughlin's theory at these levels will be examined in more detail. At level two, the child supposedly can retain $2^1 = 2$ concepts. This means that he can draw comparisons and make rudimentary inferences. However, since he can retain only two concepts simultaneously, if he encounters a new object he can compare it with the original object only in terms of whether it is the same or different. In the water jars experiment, this means that when the child at level two is asked to compare the quantity in two different jars, he attends to <u>either</u> the size of the jar <u>or</u> the water level, compares it to the original and states that they are dissimilar.

At level three, when conservation appears, the child is capable of retaining $2^2 = 4$ concepts at a time. Thus, when confronted with the jars of water he can reason in terms of the classes of height and width and whether new attributes fit within these classes or not. That is, he can now perform a multiplication of these two relations which would give him four concepts to consider.

Essentially, this theory is not too dissimilar from that of Piaget, but represents another approach to an explanation of the latter's findings in terms of the mental maturity of the child. It does not, however, account for the reasons how or why children at certain ages are capable of acquiring concepts except as a function of age.

One important aspect of McLaughlin's paper is that he clarifies

a point concerning conservation that has been dealt with (and in many cases incorrectly) by a number of other researchers. Concrete operations are said to be reversible and it is during the stage of concrete operations that conservation of continuous quantity develops. Piaget has stated that the principle of reversibility is essential to the development of the concept (Piaget, 1960, pp. 138, 141). However, there has been considerable confusion as to the exact meaning of this term "reversibility". McLaughlin explains reversibility as comprising two types of actions: one in which the child performs a reverse operation called inversion, and secondly, he may utilize an operation which compensates for the original operation. The latter is called reciprocity. In the water jars experiment, the child at the concrete level of intelligence can understand that if the water is poured into a tall, slim container, the amount is unchanged because the water may be poured back into the original container and made to look the same as it did at first (inversion). He can also understand that the increased height is compensated for by the decrease in width (reciprocity). Some experimenters, (Wallach and Sprott, 1964, Lovell and Ogilvie, 1961) have not considered that reversibility is comprised of inversion and reciprocity, and have accepted either of the actions as evidence of a reversible operation.

Several researchers have attempted to discover the relationship between the acquisition of the concept of conservation and such factors as sex, age, intelligence, type of material being conserved,

visual perception and school achievement. Such studies have been conducted by : Almy (1966); Brace (1963); Bruner (1964, 1966); Dodwell (1960); Feigenbaum (1963); Freyberg (1966); Gruen (1966); Kooistra (1963); Pelletier (1966); Sawada (1966); Smedslund (1961a, 1961b, 1961c, 1961d, 1961e, 1961f); Uzgiris (1964); Zimiles (1963).

IV. ATTEMPTS TO DEVELOP CONSERVATION EXPERIMENTALLY

Quantities Other Than Continuous Quantities

One of the first of the learning studies was conducted by Churchill (1958) in which she administered a pretest of Piaget type number tasks to five year olds (N = 16) and then divided them into experimental and control groups. The experimental group was given practice in grouping, seriating, matching and ordering objects, operations which were hypothesized to increase the subjects' abilities to conserve number. The control group received no training. After testing the groups with a test identical to the pretest, the results indicated that the experimental subjects did profit to some degree from the training experience. However, the number of subjects involved in the experiment does not warrant the acceptance of these findings as conclusive evidence of the reliability of this procedure. As Flavell (1963, p. 371) points out, the procedure was "too global and heterogeneous to permit any definite conclusions as to precisely what experience did and did not influence precisely what numerical skill".

A more controlled study of number conservation was conducted by Wohlwill and Lowe (1962). In this study, the experimenters used three types of training procedures with four groups of eighteen kindergarten children (one group was a control). One group was given direct reinforced practice in counting sets of elements before and after they had been rearranged spatially. A second group was given similar reinforced practice coupled with experience in observing that addition and subtraction of elements always affected the number of the set. The third group was given experience designed to show that the spatial configuration of a set did not necessarily affect the number in the set. A fourth group served as a control. The results indicated that there were no learning effects from any of the training procedures.

Another study concerning the conservation of number was undertaken by Wallach and Sprott (1964). These investigators used a training method in which they required the subject to (1) predict whether one-to-one correspondence could be re-established between pairs of dolls and beds after the objects had been altered by addition, subtraction or spatial reorganization, and (2) reconstruct the one-to-one correspondence after these alterations had been performed. This training procedure was found to be effective for the group of non-conservers (N = 15) immediately after the training situation and again after a two to three week interval. In addition, the authors claim that the training transferred to a new set of different objects

and was not extinguished despite a non-conservation suggestion which was made by the examiner.

Wallach and Sprott explain the success of their training by maintaining that the crucial variable in conservation is "reversibility". They claim that their training procedures were specifically designed to lead the child to the understanding that if the objects were placed in a one-to-one correspondence again, there would be the same number of objects as they started with. However, this is not complete reversibility but only one aspect, that aspect which McLaughlin (1963) terms "inversion", that is, the understanding that an inverse operation will return the objects to their original state.

Piaget has already indicated (Piaget, 1952, 1960) that some children are capable of mentally returning to the starting point without understanding conservation, and that this type of action is not true reversibility. This fact, coupled with McLaughlin's theory of an additional aspect inherent in reversibility would serve to throw suspicion on Wallach and Sprott's claim that reversibility (as they have defined it) is the crucial element in conservation.

Additional support for this reluctance to accept Wallach and Sprott's reasoning comes from a study by Lovell and Ogilvie (1961) on the conservation of weight and substance. In this experiment, the authors used Piaget's plasticine balls method to test for conservation. They report that forty-six percent of the non-conservers

were able to recall that the balls were equal before any transformation of shape was affected on one of the balls. Hence, these authors state that if reversibility is defined as the ability to show an awareness of the equality of the balls prior to the transformation, then reversibility cannot be said to be a sufficient condition for conservation.

One other study of conservation of number remains to be described, this is an experiment reported by Beilin (1965) in which he employed four training methods with 170 children ranging in age from five to eleven. The only one of the four procedures which produced significant gains over a control group was a verbal exercise which Beilin terms "Verbal Rule Instruction". It seems doubtful that the learning of a verbal rule would facilitate cognitive reorganization and so aid in the acquisition of the conservation concept. A close examination of Beilin's methods reveals that his posttest method and materials were very similar to those used in his training situation. In this case, it could well be that the subjects merely learned a type of response which the posttest materials would elicit and that such superficial learning might not transfer to other materials or new and different situations calling for an understanding of the conservation principle. This, in fact, appears to be the case as Beilin (1965) and Beilin et al. (1966) have indicated.

Several studies have focused on the effects of training on

conservation principles other than that relating to number. Smedslund, in a series of six papers (1961a, 1961b, 1961c, 1961d, 1961e, 1961f), reports the results of a series of investigations on the conservation of substance and weight. In the first paper, Smedslund reviews the theory and relevant experimentation dealing with the development of Piagetian concepts in general and specifically those aspects concerned with the conservation of substance and weight.

In the second paper, he describes an experiment in which he used two training methods in an attempt to facilitate conservation of weight. One group (N = 16) of subjects were given practice in observing the effect of adding or subtracting pieces to or from a large plasticine ball before and after comparing it to a standard by means of a balance. A second group (N = 16) practiced predicting whether or not two equal balls would be the same weight after one had been deformed. This group also tested their predictions by means of a balance. A third group served as a control. The results of the posttest indicated that while there was some improvement from pretest scores, none of the differences were significant.

Smedslund's third paper describes an experiment in which he found that subjects (age five to seven, N = 24) who had acquired conservation by means of a training program similar to that described in paper two (1961b) regressed to non-conservation when an attempt was made to extinguish their conservation responses. On the other

hand six of thirteen subjects who had acquired the conservation concept through natural means resisted the extinction suggestion.

Smedslund interprets these findings as supporting Piaget's equilibration theory and refuting a S-R or reinforcement theory. The fact that seven of the thirteen subjects who had obtained the conservation concept naturally were unable to resist the extinction suggestion throws some doubt on the validity of this interpretation.

The fourth paper presents a report of an experiment in which Smedslund attempted to force his subjects to disregard visual cues and search for a more reliable means to explain conservation. Eleven non-conservers were given experiences designed to show the unreliability of perceptions in a series of thirty-six training trials. Results for this procedure as measured by posttests of conservation of substance and weight showed that the training had no effect on the children's ability to conserve.

The fifth paper in the series reports a different approach to the conservation problem, one based on what Smedslund terms "cognitive conflict". In one of his previous studies, he had noticed that some children appeared to discover conservation if the problem involved both deformations and addition and subtraction. Smedslund hypothesized that cognitive conflict might result if a subject had to combine his impression that a change in shape leads to one type of inequality with his understanding that addition or subtraction of material would also result in another type of

inequality. The resolution of this conflict was hypothesized as resulting in conservation. Accordingly, Smedslund involved thirteen non-conservers in a training situation in which this form of cognitive conflict was presented to them. No control group was used, and only five of the thirteen children showed any improvement in their understanding of the concept.

The sixth and last paper in the series is essentially a replication of the fifth experiment with the inclusion of a control group. Its results add further tentative support to Smedslund's cognitive conflict hypothesis.

Conservation and training effects in another area, that of length and area measurement, have been studied by Beilin and Franklin (1962). These authors used a verbal instruction method in which they elicited answers and stressed generalizations regarding conservation with a group of first and third grade children. An alternate form of the pretest was adminstered as a posttest. The results indicated that both the experimental and control groups of first graders improved on length measurement (the third graders were already proficient in this respect) which suggests that the pretest acted as some form of training experience in itself. In the case of area measurement, the results indicated that the training did have some effect on the acquisition of the concept but only for the third graders. Whether this means that the third grade children learned how to conserve area or measure area, or whether they merely learned how to apply rules

learned by rote memorization is not made clear in the report.

A recent attempt to induce conservation of substance is reported by Lefrancois (1966). In this experiment, the author used a hierarchy of nine related tasks which were hypothesized to lead the subjects to an understanding of the concept. These tasks were presented to two groups of non-conservers (N = 19, 21) ages five to six, in two different training procedures. In one method (called the verbal method) the subjects were asked to explain or justify their responses, while in the second method (the non-verbal method) no such explanations were elicited.

The results of the experiment indicated that both methods were effective in helping the subjects attain some understanding of conservation as measured by the posttest and that this effect was still evident when the subjects were re-tested after approximately a two week interval. In addition, it was evident that the verbal method was superior to the non-verbal method.

The fact that the verbal method was more effective could be interpreted as meaning that the concept was more firmly set in the child's mind as a result of having him verbally explain why he thought as he did. The fact that the hierarchy of tasks helped in the acquisition of the concept provides further support for Piaget's claim that learning may take place if complex structures are based on simpler structures (Piaget, 1964).

The only study to date dealing with training effects and the

conservation of discontinuous quantities appears to be that of Feiganbaum and Sulkin (1964). Discontinuous quantity is a Piagetian term and refers to quantities such as beads which can be counted into containers and still be poured back and forth. These investigators employed three methods of training for the conservation concept with forty-seven six and seven year olds who showed no knowledge of the concept on a pretest.

Method one, reduction of irrelevant stimuli, consisted of blindfolding the subjects (N = 30) and then having them count equal numbers of beads into two containers. One container was then poured into a tall thin glass and the subjects were asked whether these were the same number of beads in each glass. The second method, reinforcement by addition and subtraction, involved having the subject (N = 17) watch while beads were either combined with or removed from a pile of beads. After each combining or separation the subject was asked whether the number of beads had changed or not. The third method was a combination of each of the above and involved sixteen subjects from each of the previous groups.

The results of the study showed that the first method was effective for fourteen of the thirty subjects, method two was successful for only three of the seventeen subjects in that group and method three was not successful at all. After a one week period ten of the fourteen conservers from group one retained the concept as did two of the three from group two.

Despite the relatively small numbers of subjects who learned from their experiences and the very short interval between posttest and retention tests, the degree of success Feigenbaum and Sulkin obtained suggests tentative support for a training method which would shield the child from his own perceptions in conservation tasks. Further support for this approach is found in some of the studies reviewed in the following section.

<u>Conservation of Continuous Quantity</u>

Of the many studies concerned with the acquisition of conservation, relatively few have been devoted to the area of continuous quantity. In fact, a survey of recent literature reveals that there are only six studies and that it is questionable whether some of their results are reliable in view of their lack of controls and design. It is also interesting to note that with the exception of one study which was reported in 1961, the remainder were all published in either 1966 or 1964. Obviously, this particular area of conservation has not been studied very thoroughly and what attention it has received has been very recent.

The earliest study reviewed here is that of Feigenbaum (1961) who administered several tests for the conservation of continuous quantity to 146 children, ages four to seven. The findings of this study were that: this conservation concept is highly correlated with age; there is a corresponding developmental shift away from

relying on perceptual cues and a greater reliance on logical and arithmetical procedures; conservation is also correlated with intelligence; some training procedures facilitate conservation, others have little effect; and there is a slight tendency for performance level to vary with task parameters, especially in younger subjects (e.g., reducing the number of beads in the jars makes the problem easier).

The next three studies are all reported briefly in a recent book by Bruner (Bruner et al. 1966). The first is a study by Nair (1966) in which she investigated whether the judgement of identity is related to the manner in which one considers the equivalence of two quantities. Forty five year old subjects were pretested for their knowledge of conservation and were divided into two equal groups. In one group all the subjects had the conservation concept, in the other group, none of the children understood it. The subjects and the examiner poured equally filled containers of water into several other containers of various sizes. In each case, a wooden duck "owned" the water and "took it with him". The subjects were questioned as to the equality of the water after it had been poured and also concerning the identity of the water, i.e., whether it was the <u>same</u> water as the duck had before it was transferred.

The results indicated that sixty percent of the non-conservers thought that transferring the water to a different size "lake" resulted in a change in the amount of the water. Even among the

conservers thirty-six percent of the subjects reasoned in a similar fashion. Subjects who recognized equality of quantity also realized that it was the same water, however, the reverse did not hold true. Bruner claims that this suggests that "recognition of identity is a necessary if not sufficient condition for the recognition of quantitative equivalence", (Bruner, 1966, p. 189). This conclusion, while tentative, seems to be invalidated by additional results of the study which show that thirty-five percent of the non-conservers did recognize the identity of the water after it was poured but still maintained that it was a different amount of water at that time. One other peculiar feature of this study is that Nair reports that twenty percent of the subjects who were originally classed as non-conservers were able to recognize the conservation and the identity of the water in the training situation. This would lead one to question the procedures used to classify the subjects at the beginning of the experiment.

The most interesting findings of the study concern the reasons children gave for their judgements of equality. Eighty-five percent of the subjects who thought that the quantity of the water changed when it was poured used perceptual arguments to defend their responses. Of those who recognized that the quantity of the water was unchanged, sixty-seven percent used non-perceptual arguments. Ripple points out that this leads to the hypothesis that children need some form of an "internalized symbol system to insulate

their thought processes from the misleading perception of the visual display" (Ripple, 1964, p. 58).

Bruner (1966) suggests that children who are conservers already have an understanding of "identity" established in their cognitive system. That is, conservers possess the understanding that the quality of a fluid is not altered by transformations. He further states that if the child is reminded about identity, prior to asking questions regarding the quantity of the substance, conservation responses will be stimulated. It would appear from Nair's findings that a knowledge of identity is present in some children who do not conserve, but it could be that this notion is not integrated with the notion of invariance of amount. In this respect, Bruner (1966, p. 192) suggests that "general intellectual growth may depend to some extent on sheer 'channel capacity', the ability to register on several aspects of the situation at once". This argument is very similar to the theory of McLaughlin (1963) in which he claims that mental ability is related to memory capacity and the growing ability to handle greater numbers of concepts simultaneously.

The second study reported by Bruner (1966) was conducted by Frank (1966) in which a screening technique was employed to prevent the subjects from centering on their initial perceptions. The theory behind this study was that if children could be shielded from their initial misleading perceptions of the situation, and

asked to represent the situation verbally (Bruner's symbolic mode of representation), then perhaps language would serve as a guide to organize their perceptions in a new manner. The study was conducted with forty children ranging in age from four to seven. Each child was given the classical pretest of conservation of continuous quantity. The training sequence consisted of having children watch while various containers were filled behind a screen. Four pairs of beakers were used: two the same size; one standard, the other taller; the standard and one wider but the same height; and the standard and one taller and wider. First the pairs with one half full of water were shown to the subject, then placed behind a screen so that only their tops showed. The water was then poured into the second container and the child was asked questions about the equality of the water in the second container. The children never saw the results. In the second part of the study, the pairs of beakers were presented again without the screen and the child was asked to predict how high water would be if it was poured into the second beaker. In the third part, the pairs of beakers were presented again and the child was asked to indicate the level of the water in the beaker which was half full. Both containers were then placed behind the screen, the water was poured into the second container and the child was asked to draw a line on the screen where he thought the water would be. Then for the first time the screen was removed and the child was able to observe the accuracy of his prediction.

The results of this study are very interesting and indicate that comparing the subjects' responses from pretest to screened test (parts I and II) the four year olds increase in correct equality judgements from zero percent to fifty percent; the five year olds from twenty percent to ninety percent; and the six and seven year olds from fifty percent to one hundred percent. However, when the screen is removed (part III), all the four year olds reverted back to their original inability to conserve while most of the five year olds retained the judgements of equality as did all the six and seven year olds. When an alternate form of the pretest was administered as a posttest, the results showed that the four year olds seemed unaffected by their previous experiences, the five year olds improved from twenty percent correct judgements to seventy percent, and the six and seven year olds improved from fifty percent to ninety percent.

These results would seem to suggest that the ability to rely less on perceptual cues to define the amount of liquid is a critical step forward towards conservation and that this ability may be facilitated by a perceptual screening technique. Bruner further claims that reversibility and compensation alone do not produce conservation since there are many instances of children who do not conserve using these aspects to explain their non-conservation responses. However, the examples cited (Bruner, 1966, p. 200-201), appear to involve reasoning based on inversion and not reciprocity

(as defined by McLaughlin (1963)) and very little if any dependency upon compensation as a justification.

The third experiment reported by Bruner (1966) attempts to shed more light on the relationship of reversibility and compensation as factors in conservation. Unfortunately, this study by Carey (1966) is rather limited both in its description of the procedure and in the lack of controls. In the experiment, nineteen four and five year olds who showed no knowledge of conservation on the classical pretest took part in a series of five "tests". Two identical beakers, one half full, the other empty were placed before the child. The subject was then shown five pairs of partially filled beakers and told to choose the one which would give him the same amount of water as there was in the original set. Each of the beakers in the set of five was of a different size and shape as compared to the original pair.

The results of the experiment indicated that half of the four year olds' choices and half of the five year olds' choices were correct. On a posttest the four years olds showed no evidence of conservation and only two of the fives improved their responses. According to Carey, about one-third of the subjects defended their choices by referring to some form of a compensatory argument. While the study had its limitations, it indicated that very young children can understand some degree of the necessary compensatory relationships involved in conservation.

A recent study by Sigel et al. (1966) reports the results of a

different approach to training for conservation tasks. This study was a preliminary investigation and involved a very small sample (10 experimental subjects, 10 control) all of whom had IQs over 130. The ages of the subjects ranged from 4.3 to 5.0. The rationale for the study was that in order to conserve, a child must understand certain prerequisites and that these prerequisites can be taught to a child, thus affecting his ability to conserve. Sigel identified the following mental operations as the necessary ones for conservation: multiple classification, multiple relationality, and reversibility.

Each of the subjects was given a pretest of conservation of substance, continuous quantity, weight and volume. A group training procedure was then initiated in which the children met with an experimenter and took part in experiences in which they practiced multiple classification of objects, discussing the multiple relationality of these objects and finally experiences designed to show them, that no matter how a number of pennies were divided among them, the total remained the same. This latter experience was termed experience in reversibility. The training session was followed by a posttest.

The results of the experiment showed differences between the control and experimental subjects in respect to all four areas of conservation. However, these differences were statistically significant only for the areas of substance and weight. The authors interpreted the results of their study as supporting their claim that

training in prerequisite operations can affect conservation concepts. Furthermore, they state that encouragement to verbalize in conjunction with the prerequisite operations may lead the child to a more rapid understanding of the concept. Based on this position, it would appear that Bruner's theory of modes of representation is supported and that training in conservation *per se* need not be taught in order to help children acquire the concept.

The last study to be reviewed in this section is that of Brison (1966). In this study twenty-four non-conservers (ages 5.4 to 6.4) were trained in groups of six subjects together with two partial conservers. A group of twenty-six matched control subjects received no training. The training procedures involved offering the children drinks of juice first from two similar but unequally filled glasses and then from two dissimilar and unequally filled glasses. Subjects who chose the correct glass (the one with the most juice) were asked to explain the reasons for their choices to the other subjects. A similar procedure was carried on in a second training session on another day. At the end of the training sessions a posttest similar to the pretest was administered. In addition, the latter included two extinction items in which the examiner presented the subject with contrived situations which apparently did not follow the conservation principle.

The results of the study showed that a significant difference occurred between the control and experimental groups as a result of the

training (twelve of the twenty-four subjects showed some evidence of conservation after training). Five of the experimentally trained subjects resisted the extinction items but only two subjects resisted both items.

Brison explains his results by claiming that the children had the expectation that the narrow containers had more juice but that this expectation was reversed and in order to obtain more juice they had to understand the reasoning in the training situation. A logical explanation was offered by other subjects who apparently understood the situation and this, Brison argues, led the non-conservers away from their dependency upon perceptual cues. The author likens this to a state of Piagetian disequilibrium and claims that the condition of socialization in the group demanded that the child reorganize his cognitive structures. The latter is open to question as Piaget himself has stated (Piaget, 1964, p. 13) that social transmission alone is insufficient to explain the development of structures. He claims that a child can receive valuable information from another only if he is in a state where he can understand this information. That is, he must already possess a cognitive structure which will permit him to assimilate this new information. Hence, to imply as Brison does, that the child's cognitive structures were further developed by the training he received is to contradict Piaget.

In view of the above, it would appear that while Brison's explanations are lacking in precision, his methods are worthy of

further investigation since they appear to have had an effect on the acquisition of the concept.

V. SUMMARY

It is apparent from the preceding review of the literature that there is increasing interest in the formation of children's conservation concepts but that relatively little work has been done in the area of concepts of conservation of continuous quantity. Recent studies have turned their attention to the effect of various forms of training in an attempt to facilitate concept development, however, the results indicate that the methods have had limited successes with no one method being completely successful for the purposes for which it was intended.

The training studies that have achieved some measure of success have had at least two aspects in common; they have utilized some form of perceptual screening to prevent the subjects from centering on misleading visual cues (Feigenbaum and Sulkin, 1964; Frank, 1966) and, or, they have employed some form of a verbal situation which required the child to explain his responses (Brison, 1966; Siegel et al. 1966; Lefrancois, 1966).

One of the questions which none of the studies has answered is whether these limited successes are due in fact to the training procedures leading to a development of new cognitive structures in the subjects, or whether they have merely aided the child to reorganize

existing structures. Piaget would argue that children cannot understand conservation concepts until they possess certain mental structures and that training will not serve to develop these. However, the success already attained while admittedly rather limited, would seem to indicate that if Piaget is correct, then the only explanation for the acquisition of the concept must be that the training situations have helped the child to reorganize existing structures. If this is the case, then Piaget's age-stage relationships for the concept of conservation must be wrong which would imply that children do possess the requisite abilities before the ages Piaget lists. The subsequent chapters of this report shed additional light on this aspect.

CHAPTER III

THE EXPERIMENTAL DESIGN AND STATISTICAL ANALYSES

I. A DESCRIPTION OF THE PROCEDURES

The procedures followed in this study involved the administration of a pretest of conservation of continuous quantity to a stratified random sample of grade one subjects who were then classified according to their knowledge of the conservation principle. Subjects who had little or no knowledge of the concept were randomly assigned to experimental and control groups. The experimental group was further sub-divided into groups of ten subjects who took part in short training sessions. The control group received no training. After the training session (or an equal interval in the case of the control group) subjects were retested with the pretest. After a two to three week interval, the subjects were given a second posttest designed to assess their ability to retain the concept and their ability to transfer it to a new situation.

II. THE THEORY

One of the prime concerns of this study was to attempt to help subjects acquire an understanding of the concept of conservation of continuous quantity. Previous studies (reviewed in chapter two) indicate that limited successes in this area have been accomplished and that the problem may be approached from at least two different

theoretical points of view.

Piaget's position on the acquisition of concepts is that learning may occur if more complex structures are built upon already existing structures but that the requisite cognitive operations must be present in the subject beforehand. In addition, he claims that these cognitive operations cannot be developed experimentally. The problem of ascertaining exactly what the necessary operations are for an understanding of the conservation concept has not been fully resolved to date. Piaget argues that the logical operations described in his equilibration theory are the crucial ones and that a state of disequilibrium in the subject provides the motivating force which leads to learning.

Bruner has a somewhat different approach based on his theory of modes of representation. He claims that children progress through stages of enactive, ikonic and symbolic forms of representation in the process of learning. The motivating force is derived from a conflict between the modes and is resolved only when the child alters his ideas about the problem under consideration.

From an examination of the studies to date, it is apparent that those training procedures which have achieved some measure of success have included at least one of the following techniques: (1) practice in operations which the authors have hypothesized to be prerequisite to the understanding of the concept (Sigel et al. 1966; Lefrancois, 1966; Carey, 1966), (2) some form of perceptual screening

to prevent the subject from relying on his initial observations (Frank, 1966; Feigenbaum and Sulkin, 1964), (3) a high degree of verbalization by the subjects in which they either discuss the problem or justify their responses (Lefrancois, 1966; Frank, 1966, Carey, 1966; Sigel et al. 1966). Thus, it would appear that the inclusion of these techniques in a training situation might be beneficial in terms of the success of the teaching. Why should this be the case?

The answer to this question requires a closer examination of what actually happens when these techniques are used. Practice in prerequisite operations appears to correspond with Piaget's comments about learning, but this assumes that the children already have the necessary cognitive abilities. If learning does occur, then there must be something wrong with Piaget's tests of the concepts, or his age-stage relationships as he has stated them, or his theory, or a combination of these. That is, Piaget has said that with regard to the concept of conservation, for instance, children cannot understand the principle until they possess certain cognitive structures, that these structures cannot be taught to them and that most children acquire these structures and hence the ability to conserve at about the ages of seven or eight. However, researchers using Piaget's test for conservation as a pretest, have "taught" the concept to children who were previously unable to understand it. It seems self evident that either the children possessed the ability to conserve and Piaget's test failed to discover this, or they did not possess the requisite abilities and were able to

develop them as the result of a training situation. In either case the results would tend to throw doubt on Piaget's tests or his theory that cognitive structures cannot be developed experimentally. The only alternative to this is to hypothesize that the children did in fact possess the abilities (or cognitive structures) but had never been required to utilize them in their natural environment.

The effect of the perceptual screening procedure appears to be that of preventing the subject from reacting immediately to his visual perceptions. This leaves him free to consider the logic of the problem without the confusion of a visual illusion. In other words, for a child who has not had occasion to think about the compensatory relationship between height and width, it is perfectly logical (in his mind) to assume that if the water level rises, the quantity increases. Ripple (1964), as previously noted, stresses the importance of insulating children from their misleading perceptions. In terms of reinforcement, this method may be explained as one which forces the subject to reiterate his own explanations thus setting them more firmly in his own mind. Naturally, this latter explanation would be valid only if the correct answers were repeated.

The working hypothesis adopted for the purposes of this study was that, assuming Piaget's test of conservation of continuous quantity to be valid and reliable, learning could take place if certain crucial aspects of the conservation principle were presented to the subjects in a manner which they could understand. This implied another assumption,

namely that the children already possessed the requisite cognitive abilities but had not had occasion to bring them into play in similar situations prior to this. Support for this assumption is found in the successes other investigators have had in teaching concepts as discussed earlier.

The crucial variables in the acquisition of conservation of continuous quantity were hypothesized to be: an understanding that the fluid retained its identity during transformations, an understanding of the compensatory relationships between height and width, and lastly an insight into the principle of reversibility as defined by McLaughlin (1963). Again, support for this hypothesis was based on the variables contributing to the success of other researchers who had attempted to train for conservation.

The methodological procedures to be adopted in the training were similarly derived from the experience of those who had worked in this area previously and from the writings of Piaget and Bruner. It was theorized that the perceptual screening technique would be valuable as it would prevent the subject from centering on his initial perceptions, leaving him free to consider other aspects of the situation. Similarly, it was decided that the subjects should be provided with experiences designed to give them some understanding of the crucial variables as outlined above. It was also decided that having the subject verbalize his responses and attempt to justify them would be beneficial as this might introduce an element of

cognitive conflict (cf. Smedslund, 1961e, 1961f; Bruner, 1966; Lefrancois, 1966). In addition, it was considered desirable to attempt to train the subjects in a group situation. Group methods had achieved only limited successes prior to this study (Sigel et al., 1966; Brison, 1966), but since a group technique (if successful), would hopefully be adopted by teachers in the schools, it was considered more appropriate to develop a group rather than an individual training procedure.

III. THE SAMPLE

The stratified random sample used in this study was drawn from the grade one population of the Public School System of the City of Edmonton, Alberta, Canada. The criteria used for stratification were as follows:

1) Intelligence. In order to obtain a sample of intelligence scores skewed to neither extreme, a specified range of scores was arbitrarily selected and subjects were accepted or rejected on the basis of whether or not their intelligence scores fell within this range. The intelligence test used to determine these scores was the Detroit Beginning First-Grade Intelligence Test (Revised) which had been administered by the school authorities to the entire population early in the school year. The authors of this test (Engel and Baker, 1937) report that it correlates 0.76 with the Stanford-Binet Intelligence Test. Its reliability, as

assessed using the Spearman-Brown formula, was found to be 0.91 while a test-retest method with a four month interval between tests yielded a reliability coefficient of 0.76. This test was normalized (mean 100, standard deviation 16) for the Edmonton area in 1962-1963 using the total grade one population at that time which numbered over 5000 pupils.

On the basis of discussions with school psychologists and those responsible for the normalization of the Detroit scores for the Edmonton area, the range of normalized scores used as a selection criterion was defined to be from 95 to 115.

2) English as the native language. Since parts of the testing and training procedures were highly verbal, it was deemed necessary to exclude any subject who might have difficulty with the English language. The possibilities of such difficulties was determined by discussing this point for each subject with his or her teacher.

3) Defective vision. Since the creation of a cognitive conflict depended in part upon the fact that the subject could see the materials correctly, subjects whose school records showed uncorrected visual deficiencies were also excluded from the study.

On the basis of these criteria, one hundred twenty subjects were selected. Twenty participated in a pilot study and the remaining one hundred served as the sample in the major experiment. The mean chronological age of the total sample was 6.15, and the mean intelligence quotient was 104.46. The range of the chronological ages was from 5.75 to 7.00.

IV. THE PILOT STUDY

Prior to the beginning of the main part of the study, a pilot study involving twenty subjects was conducted in order to assess the procedures and techniques and also to provide some data concerning the reliability of the tests. The group of subjects used in the pilot study consisted of sixteen non-conservers and four conservers. The non-conservers were divided into two equal groups of eight subjects each, which served as control and experimental groups. On the basis of the results of this pilot study minor revisions were made in the procedures, resulting in the techniques described below.

Since young children are known to be erratic in their responses in testing situations (Almy, 1963), it was felt that there might be some difficulty in determining whether a change in response from one test to another was a function of random behaviour in one or more of the test situations, the result of maturation, the effect of learning due to the training session, or some combination of these. Consequently, the tests in the pilot study were administered to the groups of subjects with a two to three week interval between the pretest and the first posttest. The results of this study showed that the subjects' responses were relatively stable over this period of time. That is, non-conservers who did not conserve at the beginning of the pilot study and did not receive any training did not show significant changes in their responses from week one to week three as measured by

McNemar's Test of Significance of Change. This procedure to assess the reliability of tests is similar to that used in an analogous situation by Almy (1966).

The validity of the tests may be assessed from an examination of the results (Chapter IV). According to Kerlinger (1965, p. 451-452), "whenever hypotheses are tested, whenever relations are empirically studied, construct validity is involved". Hence, one could argue that construct validity is inherent in the definition of the concept of conservation of continuous quantity and that since the subject's knowledge of this concept was tested, the resultant data and how well they may be justified by the theories upon which the study was based will serve to establish or disprove any claim for validity.

V. THE PRETEST AND CLASSIFICATION OF SUBJECTS

The Tests

The pretest consisted of four sections and was administered to each subject individually in a room separate from the rest of the classrooms. The first two sections of the test were derived from Piaget's classical test of conservation of continuous quantity as described in Piaget (1952). However, more responses were elicited from the subjects than in Piaget's original test.

Section I.

In section one, the subject was seated at a table facing the examiner and two identical beakers half full of coloured water were

placed before the S. The exact procedure from this point is outlined below.

Experimenter: "Here are two glasses with something to drink in them."

1. "Is there as much to drink in this glass (pointing to A) as there is in this one (B)?" If the S. agreed that there was, the E. proceeded. If S. said that they were unequal, the amounts were altered until S. was convinced that they wre equal.

A tall glass graduate was placed on the table beside the two beakers.

ITEM 1. 2. "If I poured this drink (A) into this glass (graduate) would there be as much to drink in here (graduate) as there is in here (B)?"

3. "How can you tell?"

ITEM 2. The water in A was then poured into the graduate and the following questions were asked:

4. "Is there as much to drink in here (graduate) as there is in here (B)?" If the S. replied that they were different, he was asked:

5. "How are they different? Are they really different, or do they just look that way?" Regardless of the responses to question four, each S. was asked:

6. "How can you tell?"

ITEM 3. While the graduate and beakers were still in front of the S. he was also asked:

7. "If we poured this drink (graduate) back into this glass (B), what would these two (A and B) look like?"

8. "How can you tell?"

Questions three, five, six, seven and eight were the additional questions that did not appear in Piaget's original test. Questions three, six, and eight ("How can you tell?") were included in an attempt to elicit some responses from the S.'s which would give some indication of the manner in which they were thinking about the problem and what attributes they were centering upon in forming their answers. Question five was added since it was felt that a S. might conceivably understand the conservation principle, but when asked the fourth question, he might be considering the perceptual appearance of the containers only. This in fact, frequently occurred. Question seven was added in an attempt to shed more light on the factor of reversibility, or more correctly, what has been interpreted by some authors to be reversibility.

Piaget has repeatedly stressed the importance of the factor of reversibility as one of the fundamental principles required for an understanding of the concept of conservation. In fact, he has stated that "in the absence of operational reversibility, there is no conservation of quantity" (Piaget, 1964, p. 8). Reversibility in Piaget's terms is defined thus,

> Every change is reversible. Thus . . . two relations just combined may be separated again and, . . . each operation of a group implies a converse operation (Piaget, 1960, p. 40-41).

This explanation seems to imply that there are, as McLaughlin (1963) has pointed out, two aspects to Piaget's notion of reversibility. The first is an operation which is the opposite of the original operation and the second is the separation of two relations which have been joined. McLaughlin identifies these aspects as inversion and reciprocity respectively.

Support for this interpretation of reversibility as being comprised of two elements may be found in Piaget's works. He has stated that in experiments dealing with the concept of conservation of continuous quantity, it has frequently occurred that subjects who cannot conserve will tell the examiner that a transfer from A to B may be corrected by a transfer from B to A. Piaget terms this "empirical reversibility" and does not consider it to be true or genuine reversibility as he has defined it.

Wallach and Sprott (1964) who accepted a definition of reversibility as meaning merely the ability to understand that a return to the starting point will (in the case of conservation experiments) result in restoring the quantities to their original state, have attempted to employ training procedures to develop this type of understanding in their subjects and thus, to develop the concept of conservation experimentally. Wallach and Sprott claim to have achieved some success with their method which involved training in "reversibility" as they define it. However, whether they are justified in making this claim is open to question, particularly in view of the fact that Lovell and

Ogilvie (1961) found that if reversibility was defined as Wallach and Sprott defined it, then it was insufficient as a condition to explain the acquisition of the concept of conservation.

In view of the apparently contradictory evidence concerning reversibility and its definition, the seventh question attempted to ascertain, before the child took part in a training session, whether or not he understood that a return to the starting point would result in a restoration of the quantities as originally shown to him.

Section II.

The second section of the pretest was similar to the part just described but instead of a single, tall container being used, five smaller but identical beakers were placed before the child. The questioning was as follows:

ITEM 1. 1. "If I poured this drink (A) into all these glasses (beakers D, E, F, G, H) would there be as much to drink in all these together (indicating all five beakers) as there is in this glass (B)?"

2. "How can you tell?"

ITEM 2. Again as in part one, the water was poured, this time into the five beakers and the questioning continued.

3. "Is there as much to drink in all these together (indicating D, E, F, G, H) as there is in here (B)?" S.'s who replied in the negative were again asked:

4. "How are they different? Are they really different or

do they just look that way?" In each case, all subjects were asked, "How can you tell?"

ITEM 3. While the containers were still in front of the S. he was also asked:

5. "If we poured these drinks (D, E, F, G, H) back into this glass (B), what would these two (A and B) look like?"

6. "How can you tell?"

Section III.

The third section of the pretest was designed to measure the S.'s understanding concerning the sameness or identity of the water after it has been poured into another container. The theoretical importance of this understanding has been discussed by Bruner (1966) previously in this study. Very briefly, the claims of some authors are that a child cannot understand the concept of conservation of quantity until he recognizes that the quality of the quantity does not change when it is poured back and forth or transformed in some other manner. That is, conservation is dependent upon the child's realization that pouring a fluid into another container does not change it into a new kind of fluid.

This aspect was investigated by presenting the child with two identical beakers, one partially full of coloured water, the other empty. The procedure was as follows:

ITEM 1. "We are going to pretend that we have a very special drink in this glass (indicating the partially filled one). What kind of drink

do you want it to be?" After this, the child's name for the drink was used. "If I poured the drink into this glass (the empty one) would it still be your special drink (using child's terminology) or would it be a different kind of drink? How can you tell?"

Section IV.

The last part of the pretest was comprised of a series of eight pictures showing sets of containers. See Figures 1 to 8 inclusive. Each picture showed two or more containers, one partially filled, the others empty. These pictures were used in an attempt to measure the S.'s ability to respond in a conservation problem in what Bruner (1966) has termed ikonic and symbolic modes of thought. The pictures were introduced and used as follows:

Item 1. "Now I'm going to show you some pictures of some glasses with drinks in them. Here is a picture (Card 1) of two glasses. They are both the same size and shape aren't they? This glass (pointing to the one on the left) has a drink in it. See, here is the drink in the glass (pointing to the coloured "drink" in the glass). What would happen if we poured this drink (L) into this glass (R)? Would there be as much to drink here (R) as there was over here(L)?"

A similar procedure was followed with each of the remaining seven items and sets of pictures.

The Method of Scoring

Each subject's responses were recorded by the examiner at the time of testing on a prepared score sheet (see appendix A). The S.'s

responses were marked either right or wrong (yes or no) in terms of whether they did or did not indicate a knowledge of conservation. In the case of the third section regarding the child's understanding of the identity relationship, a record was kept which merely showed whether or not the S. thought that pouring did or did not alter the identity of the fluid.

The Classification of the Subjects

Subjects were classified into three groups, non-conservers (N = 59), partial conservers (N = 21), and conservers (N = 20) depending upon their answers to the second question in parts one and two of the pretest. These questions formed the basic elements of Piaget's classical test of conservation of continuous quantity. A non-conserver was defined as a S. who gave non-conservation responses to both questions in the two parts; a partial conservers as a S. who gave one conservation response and one non-conservation response in the two parts; and a conserver was defined as a S. who gave two correct answers in both parts.

Subjects who were classified as non-conservers and partial conservers were randomly assigned to experimental and control groups. Twenty-nine non-conservers and eleven partial conservers made up the experimental group while the control group consisted of thirty non-conservers and ten partial conservers.

FIGURE 1

CARD 1, PRETEST

FIGURE 2

CARD 2, PRETEST

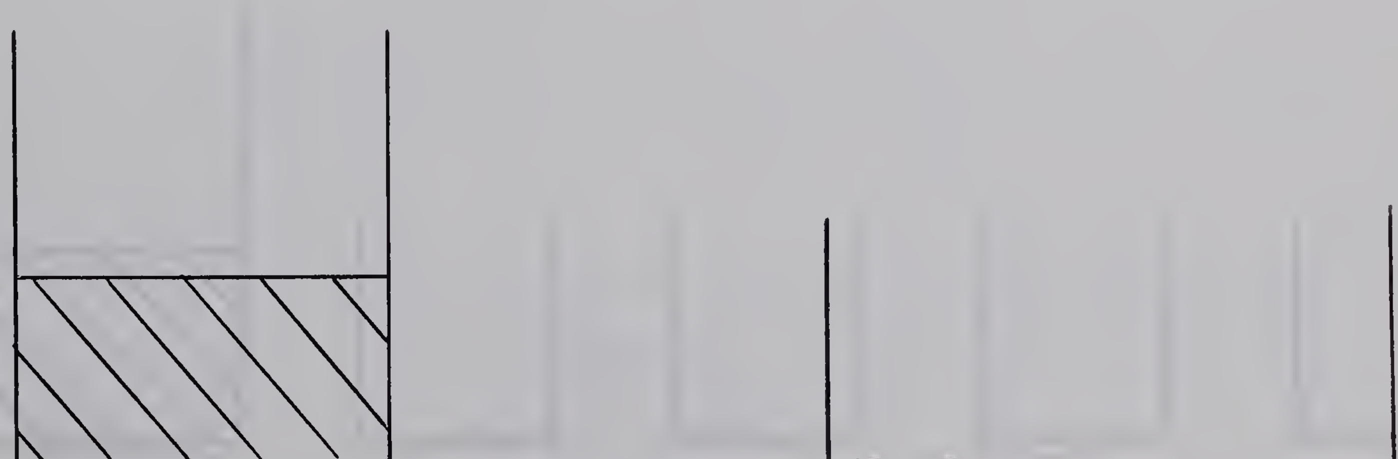
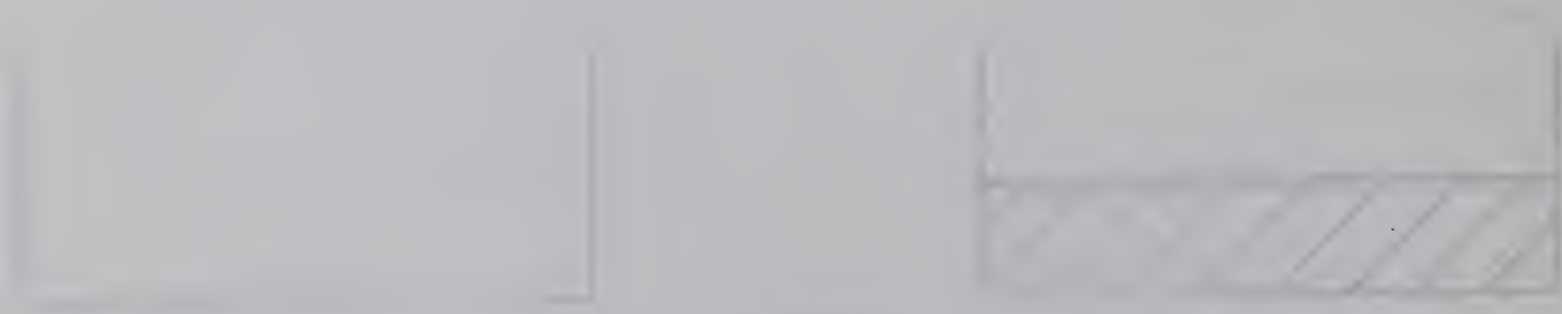
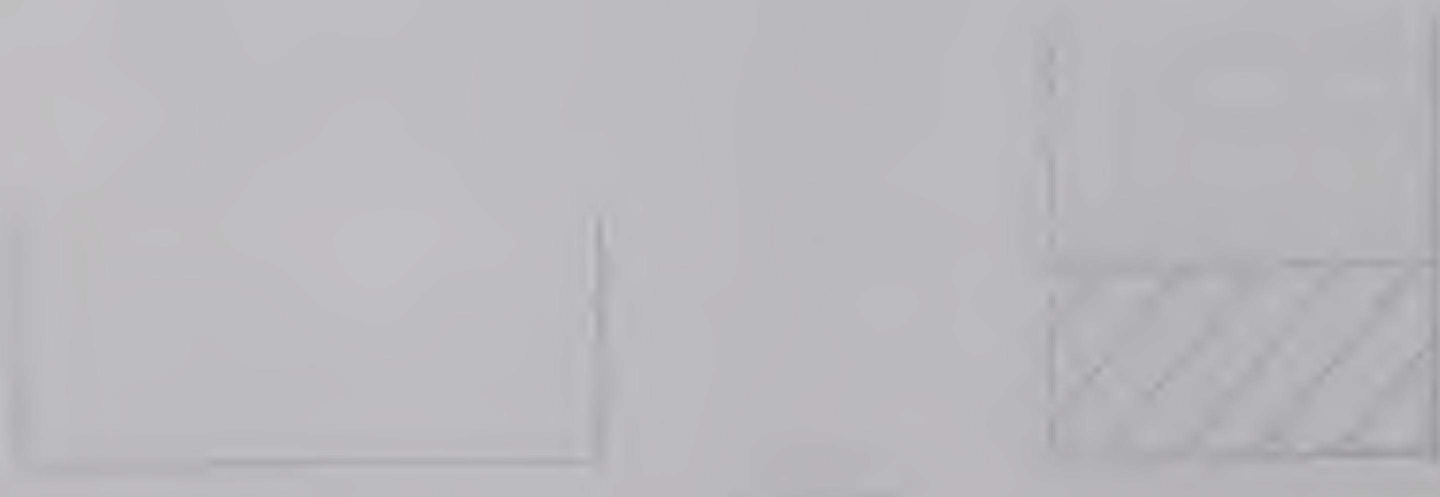


FIGURE 3

CARD 3, PRETEST





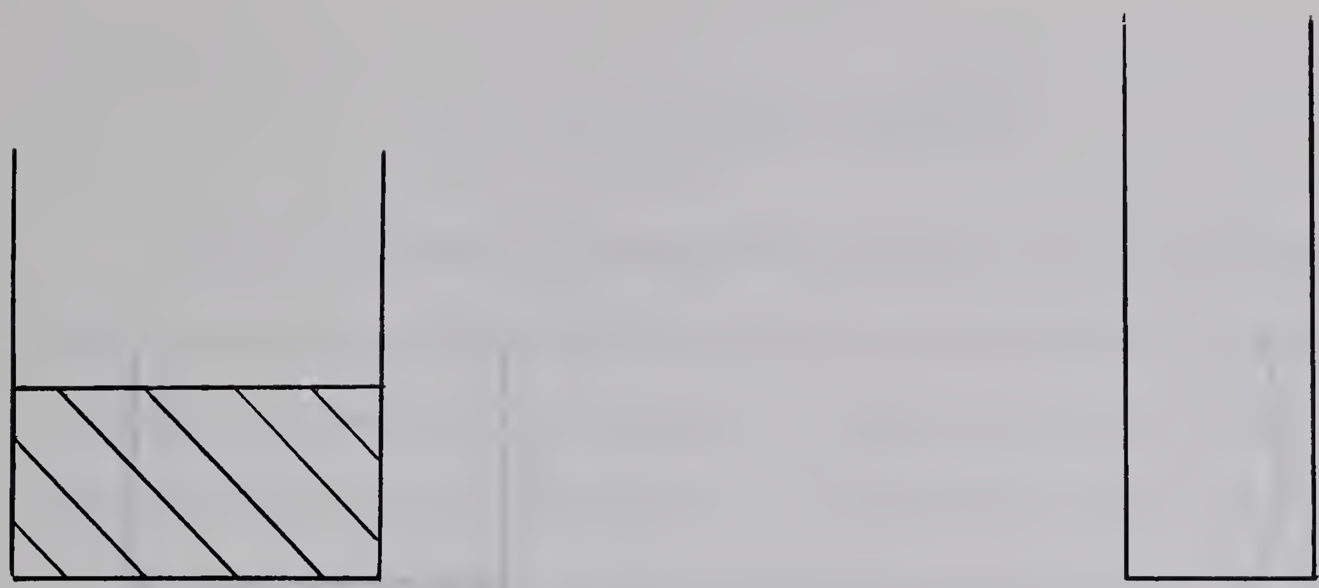


FIGURE 4

CARD 4, PRETEST

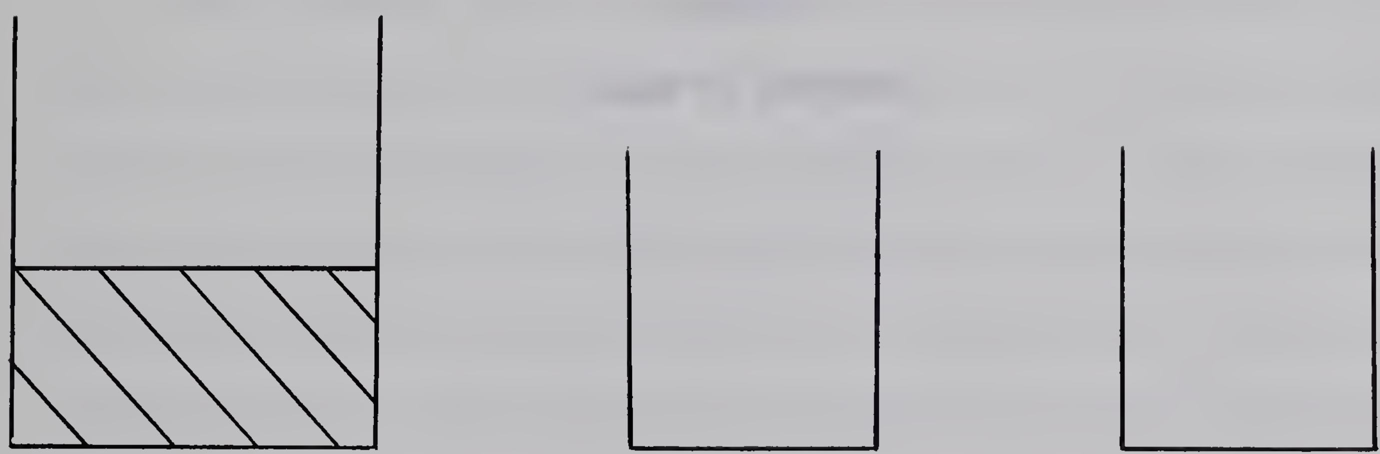


FIGURE 5

CARD 5, PRETEST

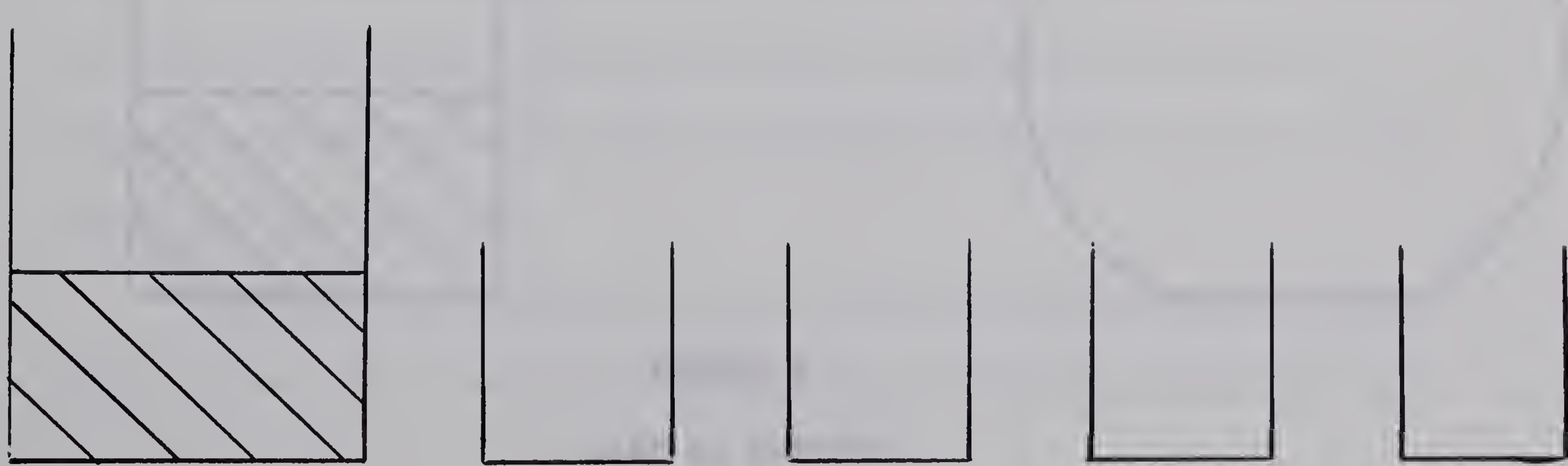
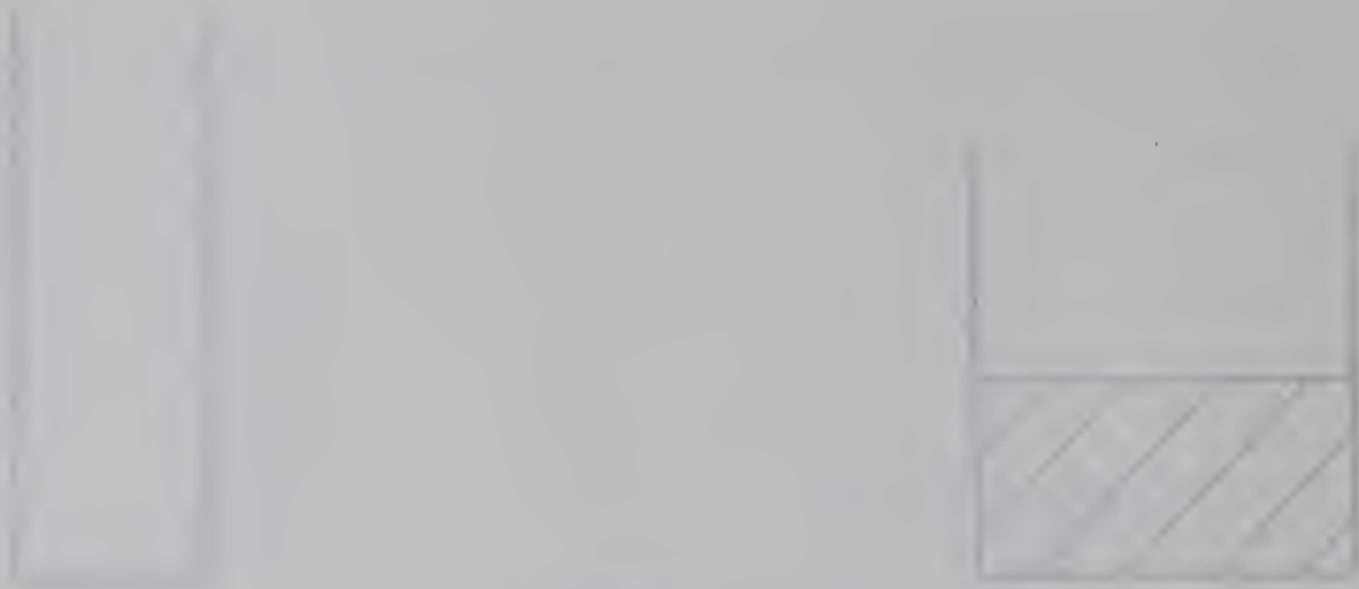


FIGURE 6

CARD 6, PRETEST



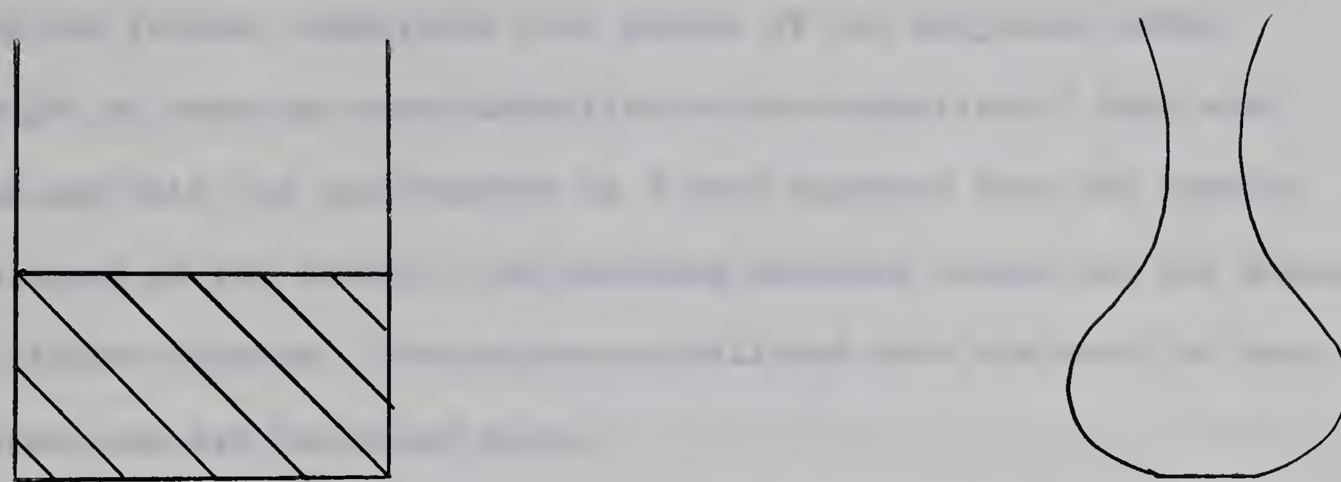


FIGURE 7

CARD 7, PRETEST

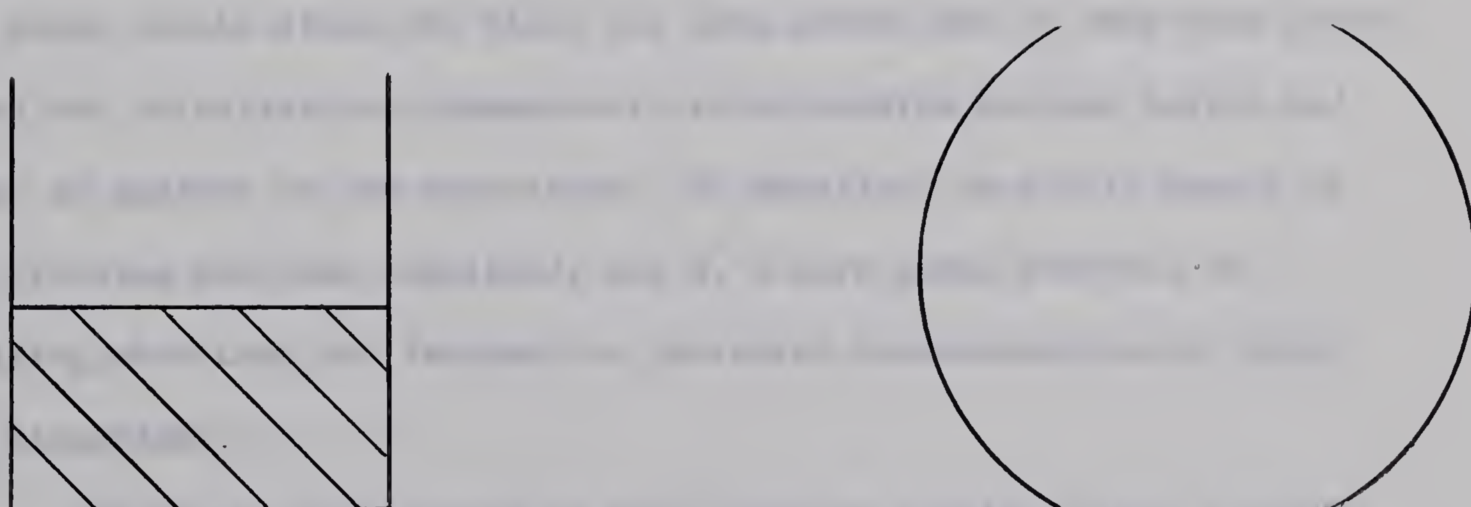
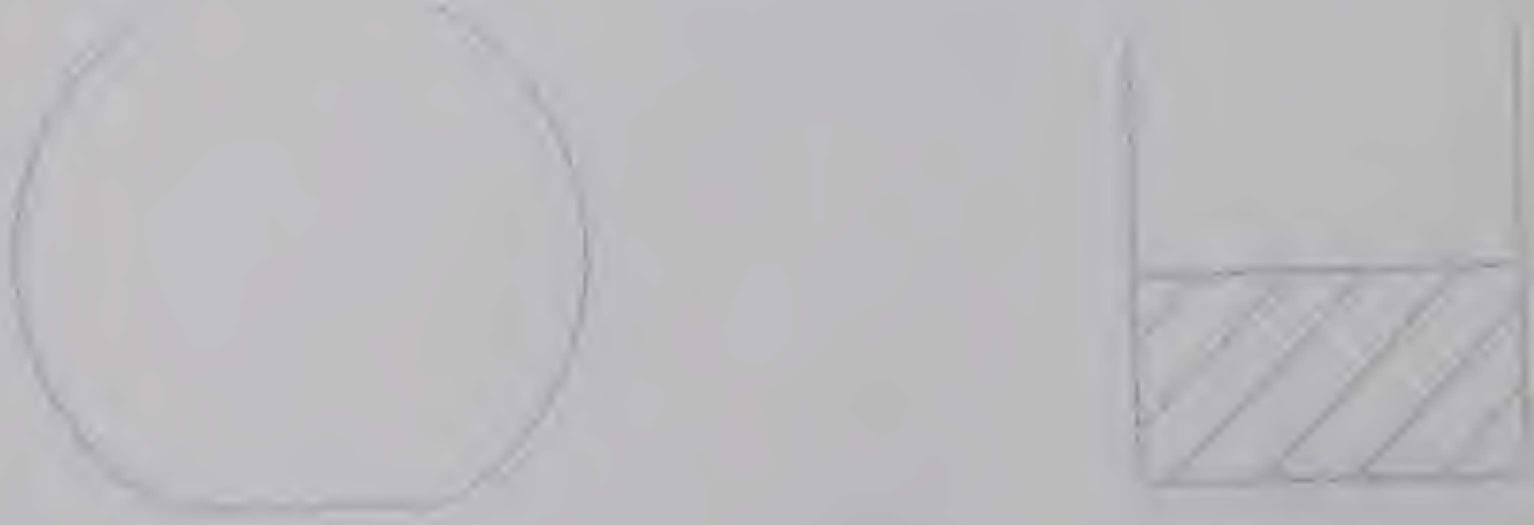


FIGURE 8

CARD 8, PRETEST



VI. THE TRAINING SITUATION

For the purpose of the training sessions, the experimental group was further subdivided into groups of ten subjects, seven or eight of whom had been classified as non-conservers. Each subgroup met with the experimenter in a room separate from the regular classrooms of the school. The training sessions lasted (on the average) for fifteen minutes. The procedures followed were the same for each subgroup and are described below.

The training session was designed to accomplish several purposes simultaneously. These were (1) to help the S.'s realize that pouring a liquid does not alter its quality, that is, that the liquid retains its identity over transformations; (2) to shield the S.'s from their immediate perceptions of the situation and at the same time help them to understand that pouring does not alter the quantity of the fluid; (3) to confront the S.'s with the changes in the height of the water levels after the fluid had been poured and to help them understand and verbalize the compensatory relationships between height and width as applied to the containers. In addition, once this aspect of the training had been completed, the S.'s were given practice in applying what they had learned, to pictorial representations of similar situations.

The exact wording used in each training session varied slightly depending upon the responses of the subjects, however, an attempt was

made to keep each session as similar to the others as possible. The general procedure was as follows.

Section one, the identity relationship. The S.'s were seated around a large table in front of the E. A variety of tin cans of various shapes and sizes but all painted the same colour were placed on the table.

E. "Today, we are going to learn what happens when we pour drinks back and forth. We are going to pretend that I have a very good drink here in this jug (showing juice container). Now let's pretend that we don't have any glasses and that we have to use some of these cans to drink from. I'm going to pour a drink into this can here. Is this drink in the can the same <u>kind</u> of drink that I had in the jug?" Children were free to respond at this point and explanations as to how they knew that it was the same were elicited. "Would it matter if we poured the drink into this can (selecting a can of a different size and shape)? Would that change the kind of drink we have?" Again responses were elicited. Where a S. gave an incorrect response, E. asked if anyone had a different answer. At <u>no time</u> did the E. say that one answer was correct or another wrong. S.'s who gave correct answers were asked to explain how they knew their answer and sometimes but not always, the S. who gave an incorrect answer was asked the question again.

After the above procedure had been used twice, the S.'s were asked, "Does pouring change the <u>kind</u> of drink?" Pairs of S.'s were

then chosen from the group to come forward. One S. selected a can and poured a drink while the other S. watched and told the group whether or not the kind of drink in the new can had changed.

Section two dealt with the understanding that the quantity did not change with transformations. The tin cans were used again and the S.'s were told that this time when the drinks were poured, we were going to be talking about how much there was to drink. E. poured a "drink" into one of the cans and then told the S.'s "I'm going to pretend that I am going to give this drink to somebody here, but I just looked into this "glass" and noticed that it is dirty. Now we can't let anyone drink out of a dirty glass can we? I think I'll pour the drink into this glass (another tin exactly the same size and shape). Would pouring it into this glass change how much there is to drink?" Answers and explanations were elicited. "What would happen to how much there is to drink if I poured it into this glass (a different size and shape)?" Answers and explanations were again elicited. This procedure was followed with various sizes and shapes of containers and then pairs of S.'s were brought forward. Each S. selected a tin and one S. poured a drink from one to the other while the remaining S. watched and reported to the group. During this procedure, the water levels of the "drinks" were hidden due to the nature of the containers.

The third section of the session was designed to confront the S.'s with the differences between the height of the water levels after

the "drinks" had been poured. The tin containers were removed and in their place specially prepared glass containers were introduced. These containers were of various shapes and sizes and were completely covered with paint except for a narrow vertical strip on the back of each container. The purpose of the paint was to prevent the S. from seeing the level of the liquid until the E. turned the container around at which time the level could be seen through the clear un-painted strip.

A similar procedure to that followed in the previous section was used here. The S.'s were advised to consider the quantity relations and the painted glass containers were introduced in much the same way as were the tin cans previously. After pouring "drinks" back and forth between various containers once or twice and discussing the effects on the quantity, the S.'s were asked to predict where they thought the level of the drink would be in each container. S.'s were invited to come forward and point out their predictions with their fingers. While they were still at the table, the container was turned so that the clear strip was to the front and the level of the liquid was visible. The S. was then asked, "Did you guess (predict) correctly? Can you tell us why the 'drink' is here (pointing to the level)?" If that particular S. could not give the answer, it was elicited from the other members of the group.

"Drinks" were poured into tall, narrow containers and short, shallow containers as well as irregularly shaped ones. In each case

a procedure similar to that just outlined was employed and the S.'s were asked to explain why the level of the liquid rose or fell in the various glasses. It is important to note that in every case before the height-width relationships were introduced, the S.'s had agreed that the quantity of the "drinks" did not change when they were poured into the various sizes and shapes of containers. In every training session an attempt was made to elicit answers from the S.'s and to have them explain the compensatory nature of the height-width relationships.

The final section of the training session concerned the S.'s abilities to relate what had just been discussed and shown to them to pictorial representations of similar situations. This was accomplished by means of a series of six drawings of sets of containers (Figures 9 to 14) similar, but not identical to those used in the pretest. Here again, S.'s were asked questions concerning the effects of transferring the quantity shown in a picture from one container to the other(s). Answers and explanations were again elicited from the S.'s

VII. THE POSTTESTS

Posttest I

The first posttest was administered to every subject in both the experimental and the control groups. In the case of experimental group, the test was given individually to the subject immediately

after the completion of the training session. Subjects in the control group received the test after a length of time equivalent to that which would have been used had they taken part in the training session.

The test itself was identical in every way to the pretest and was scored in a similar fashion. Each subject was reclassified as to his or her apparent knowledge of the concept of conservation of continuous quantity as described in the section on the pretest.

Posttest II

The second posttest was administered to every experimental subject and those subjects who had previously been classified as conservers. This test was also administered individually and in the case of the experimental group, two to three weeks after the training session. The conservers took the test after an interval of time which was equal to the amount of time which would have passed had they taken part in the training and posttest I.

The test consisted of five sections involving sets of glass containers of various sizes and shapes. This test was designed to measure not only how well the subject retained the concept he had acquired in the training session (if indeed he had acquired the concept), but also whether or not he could transfer this knowledge to a new situation using different materials. Accordingly, split peas and lentils were substituted for the coloured water used in the pretest, training sessions and posttest I. In addition, the containers used in this test were more unusual in shape than the containers previously used.

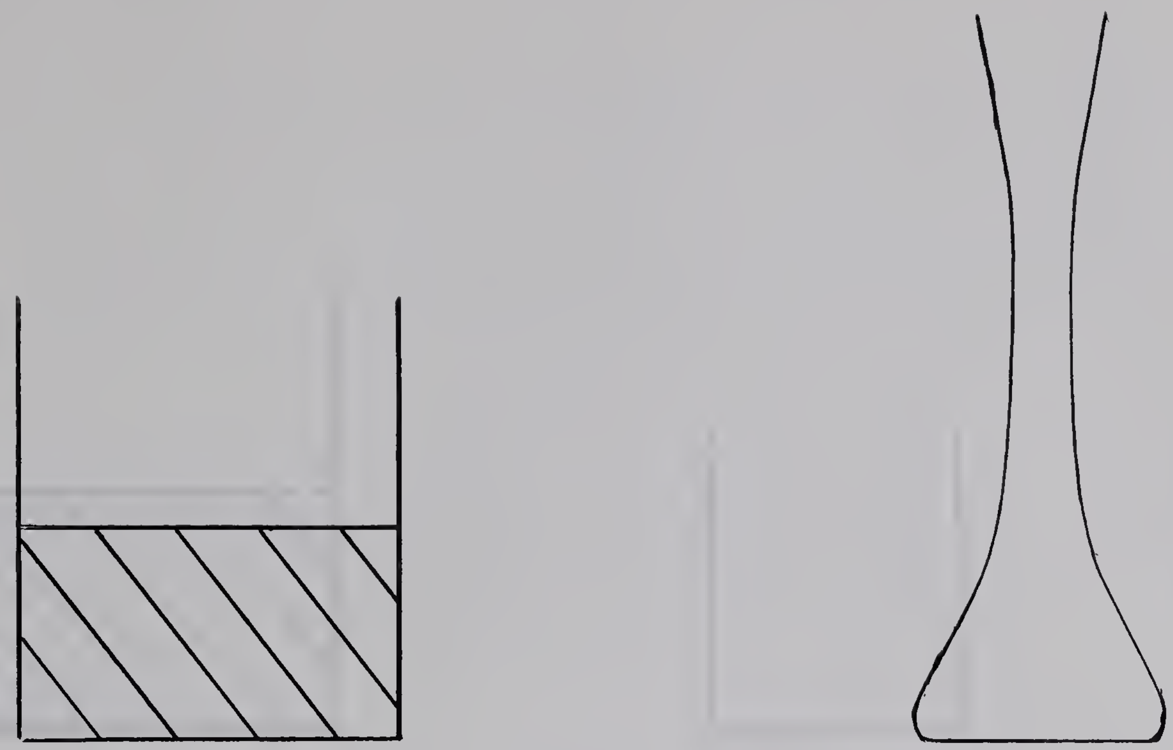


FIGURE 9

CARD 1, TRAINING SESSION

FIGURE 10

CARD 2, TRAINING SESSION

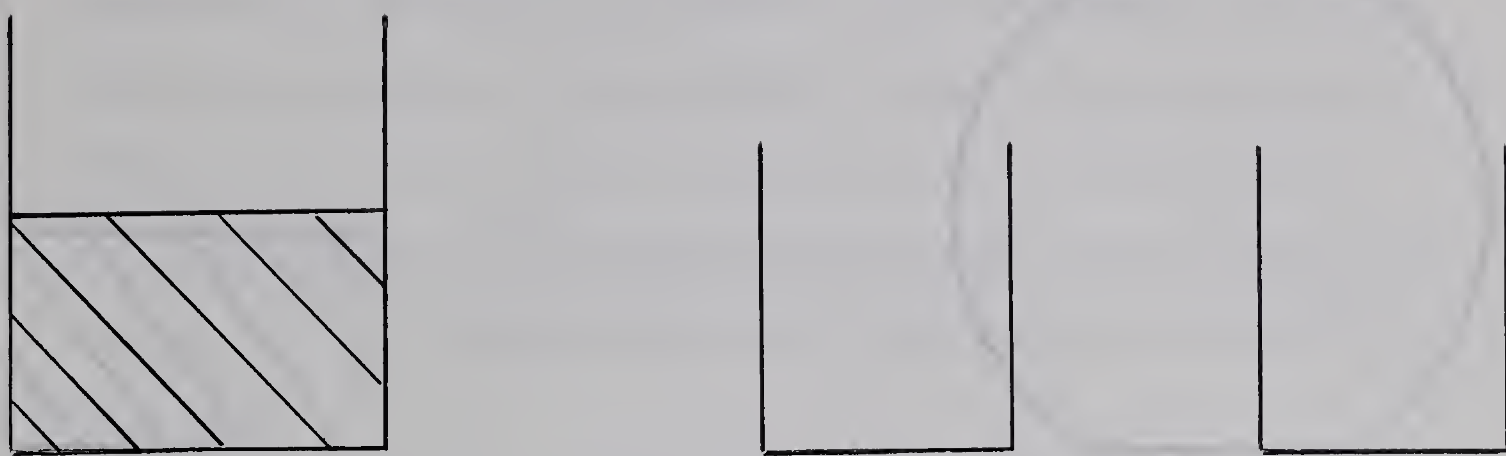


FIGURE 11

CARD 3, TRAINING SESSION

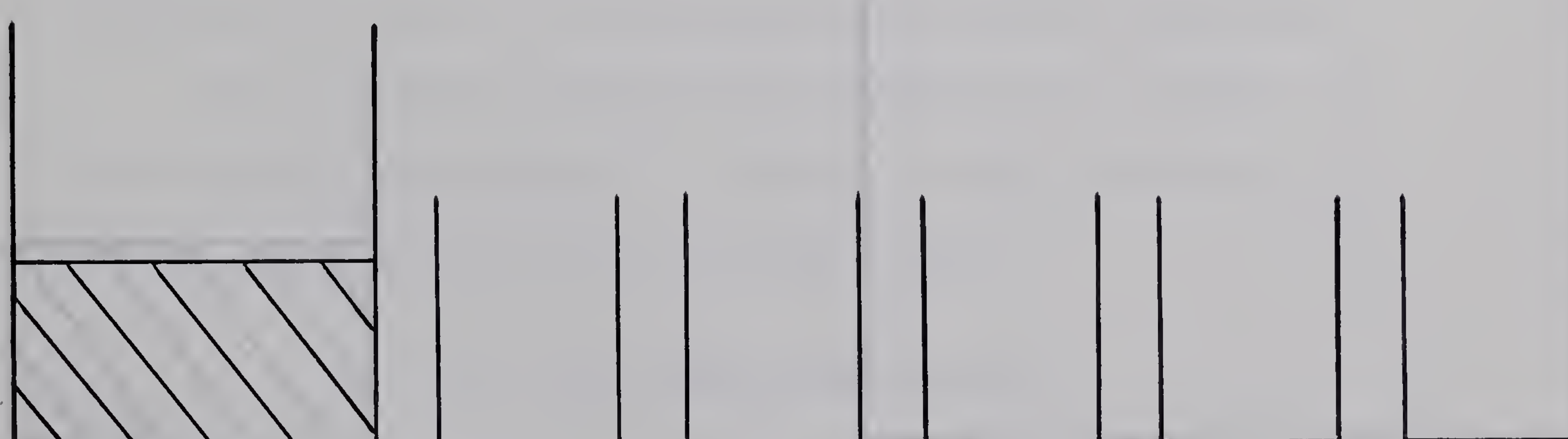


FIGURE 12

CARD 4, TRAINING SESSION

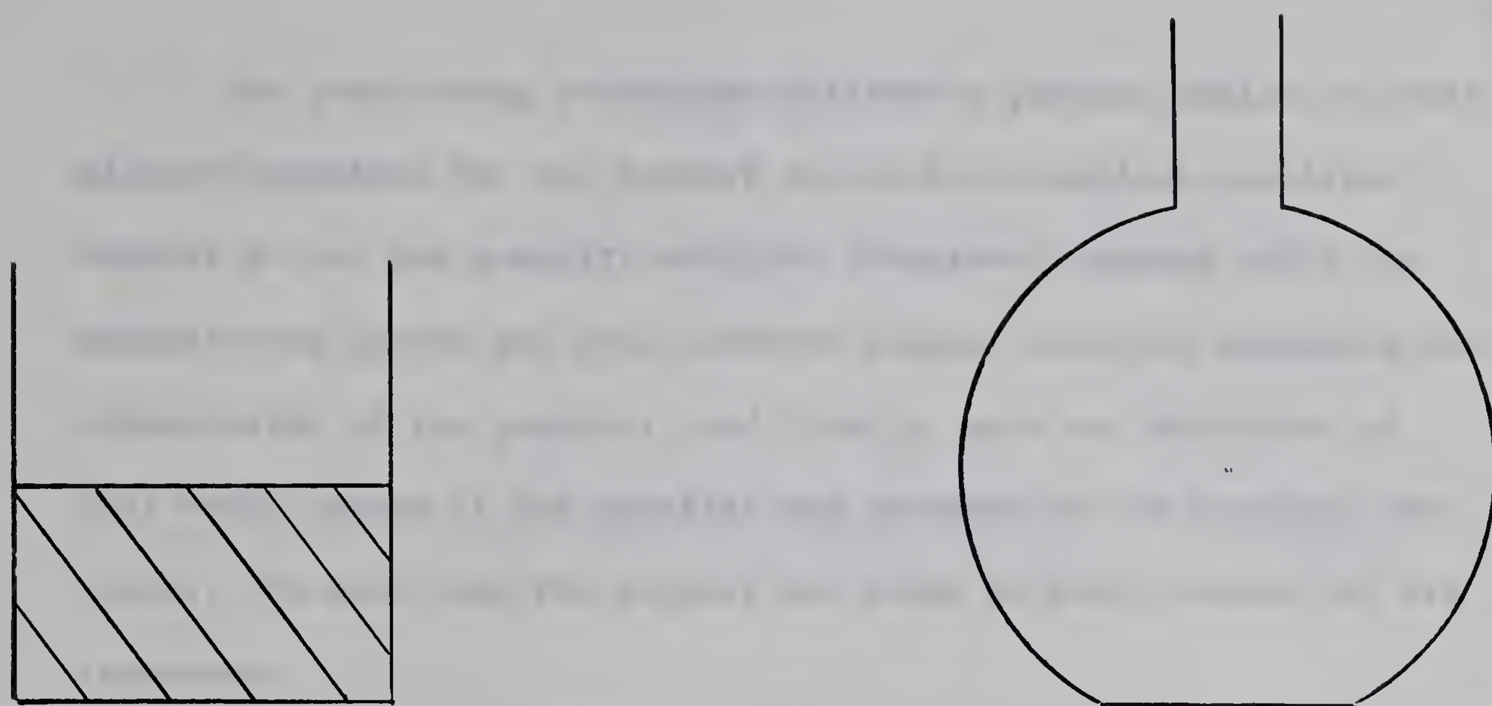


FIGURE 13

CARD 5, TRAINING SESSION

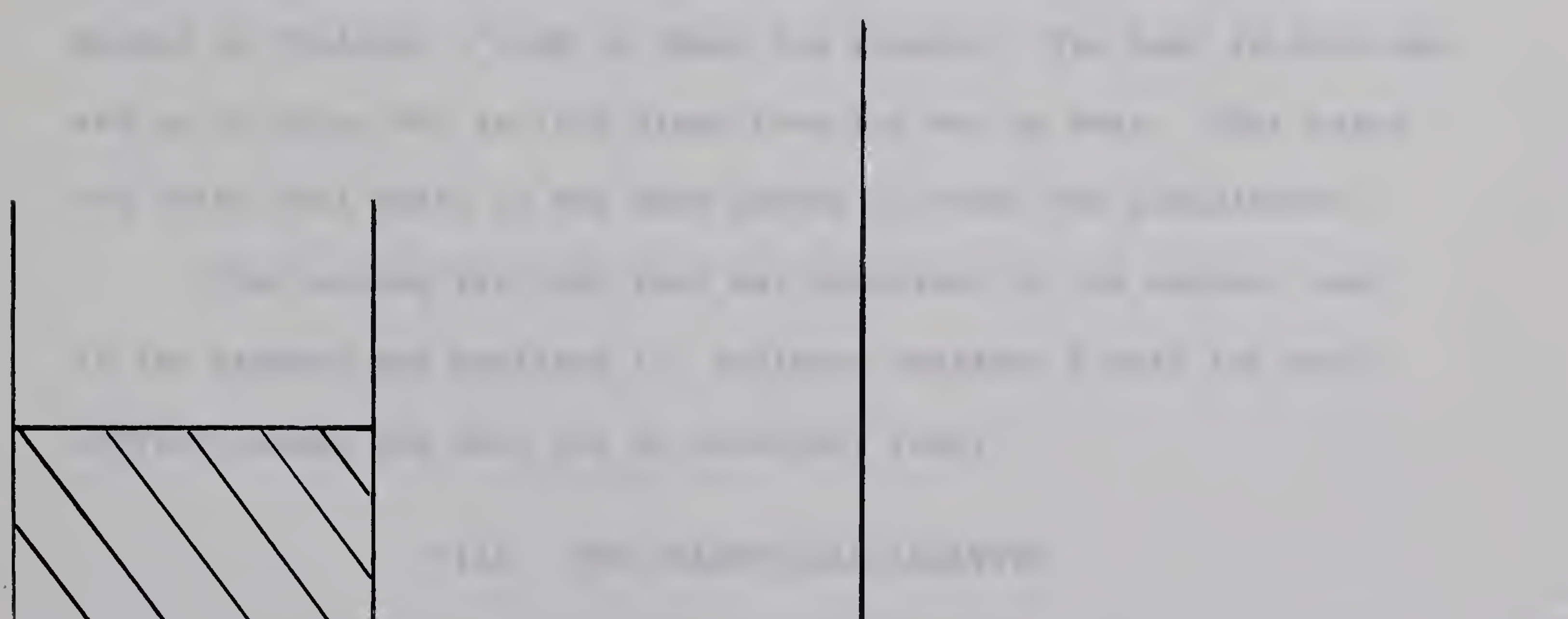
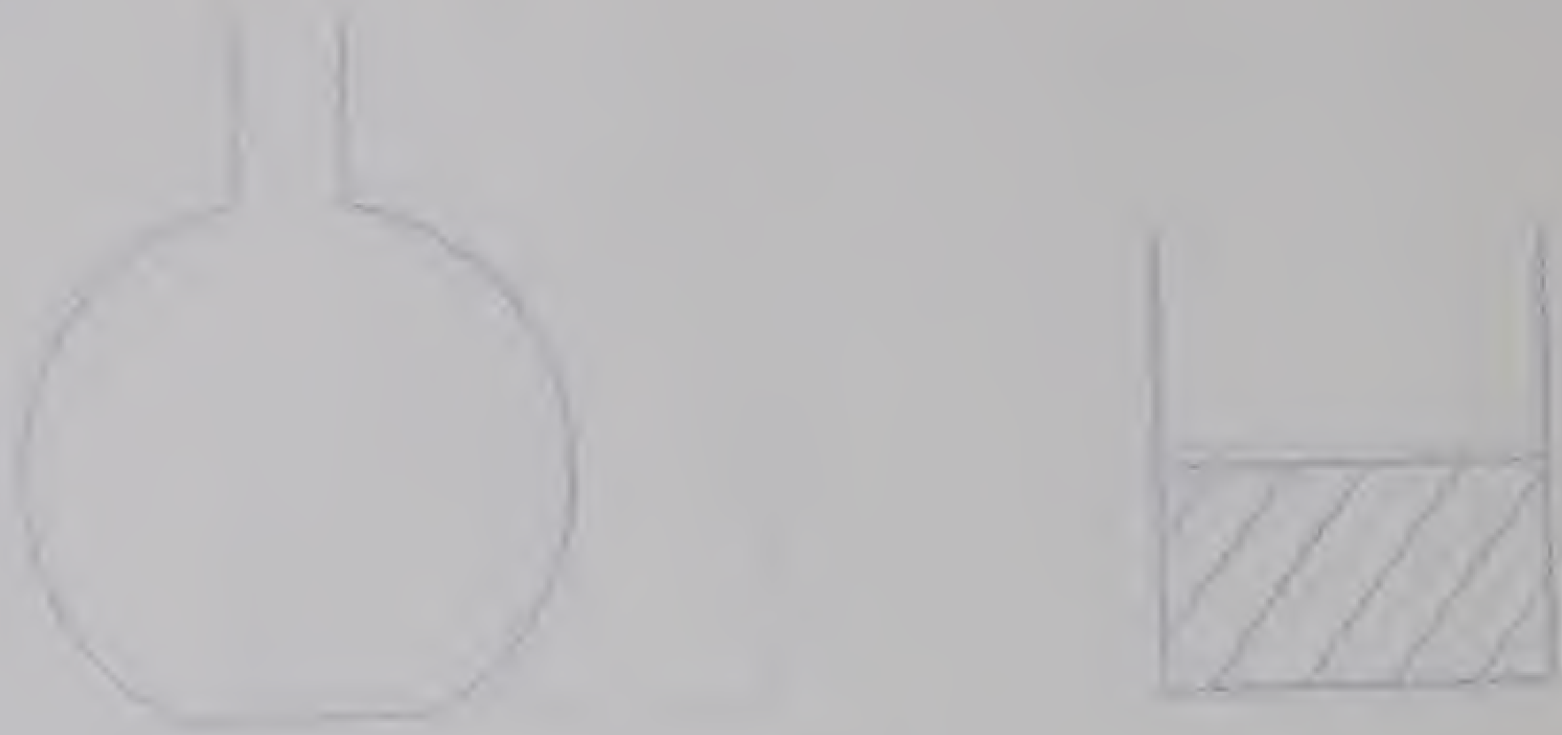


FIGURE 14

CARD 6, TRAINING SESSION



The questioning techniques followed a pattern similar to that already described for the pretest in which the subject predicted whether or not the quantity would be conserved, watched while the quantity was poured and then answered another question regarding the conservation of the quantity, and finally, gave an indication of what would happen if the quantity was returned to the original container. In each item the subject was asked to give reasons for his responses.

In section I, a question was added to the usual procedure in which an attempt was made to extinguish the subject's conservation response, or at least to suggest that his answer was incorrect. The question was asked after one of the beakers of peas (or lentils) had been poured into a container whose shape made the level of the peas rise above the level they had been in the beaker. The question was stated as follows: "Look at these two glasses. The peas in this one are up to here, but in this glass they are way up here. What makes you think that there is the same amount in these two containers?"

The scoring for this test was identical to the methods used in the pretest and posttest I. Subjects received a mark for each correct answer and zero for an incorrect reply.

VIII. THE STATISTICAL ANALYSES

Since little was known about the exact nature of the population from which the sample was drawn, and since the scoring of the

results was in the level of measurement on a nominal scale, these factors suggested the use of a nonparametric statistical test of significance. Consequently, McNemar's Test for Significance of Changes was used to test each of the hypotheses. According to Siegel (1956, p. 63),

> The McNemar test for the significance of changes is particularly applicable to those 'before and after' designs . . . in which measurement is in the strength of either a nominal or ordinal scale.

An application of the Chi-square formula used in McNemar's test involves the approximation of a discrete distribution by a continuous distribution. Consequently, there is a need to incorporate Yates correction for continuity into the computations. This procedure was followed for each application of the test.

CHAPTER IV

THE RESULTS OF THE STUDY

The results reported below refer to the responses the subjects made to the items presented to them in the pretest and the first and second posttests. The pretest required the subjects to respond to questions concerning the conservation of a liquid when it was poured first into a tall thin graduate and then into five small beakers. Other items related to the subjects' abilities to recognize the invariance of the quality of a liquid when it was poured into another container and items which involved conservation problems in pictorial form.

The first posttest was identical to the pretest while the second posttest contained items which were of a similar nature but involved new materials. Complete descriptions of these tests have been given in Chapter III.

I. THE RESULTS OF THE PRETEST

The results of the pretest are shown in Table I. For purposes of clarity of interpretation, the subjects' responses have been reported under the classifications of non-conserver, partial conserver and conserver even though these categorizations were not made until after the pretest had been administered. Throughout this chapter NC will be used to refer to non-conservers, PC to refer to partial conservers and C to refer to conservers.

TABLE I

NUMBER AND PERCENT OF SUBJECTS GIVING CORRECT RESPONSES ON THE PRETEST

Section	Item	Description	NC	%	PC	%	C	%
I	1	Predicts equality before pouring	23	37	9	40	13	65
	*2	Claims equality after pouring	0	0	11	52	20	100
	3	Predicts equality if returned to original containers	50	80	18	86	20	100
II	1	Predicts equality before pouring	21	34	9	40	13	65
	*2	Claims equality after pouring	0	0	10	47	20	100
	3	Predicts equality if returned to original containers	58	93	21	100	20	100
III	1	Recognizes the invariance of the quality of the liquid	37	60	13	62	19	95
IV	1	Predicts equality in the pictorial representations	40		20		19	
	2		37		17		19	
	3		7		9		15	
	4		4		12		18	
	5		11		11		17	
	6		7		5		18	
	7		8		11		17	
	8		8		11		18	
		Mean for section IV possible total 8	2.1		4.5		7.0	

NOTE: NC = Non-conserver (N = 59)
PC = Partial conserver (N = 21)
C = Conserver (N = 20)

The classification of the subjects into NC, PC and C took place after the pretest and was based on the responses to questions marked *.

Section I

Two equal containers and a tall graduate.

Item 1. This item required the subjects to predict whether the quantity of liquid would be the same if it was poured into the graduate. Approximately thirty-seven percent of the NC's made correct predictions while the corresponding percentages for the PC's and C's were forty percent and sixty-five percent.

Item 2. This item required the subject to state whether the quantities were the same amount after one of them had been poured into the graduate. It was also one of the items upon which decisions concerning the classification of the subjects were based. Correct responses for the three groups were zero percent for the NC's, fifty-two percent for the PC's and one hundred percent for the C's.

Item 3. In this item subjects were to state what the amounts of the liquids would look like if they were returned to their original containers. Eighty percent of the NC's said that the quantities would be equal again, eighty-six percent of the PC's gave similar answers and one hundred percent of the C's answered correctly.

Section II

This section involved pouring a liquid from one or two equal beakers into five smaller beakers.

Item 1. Prediction of equality of the amounts before pouring. In this item, correct predictions were given by thirty-four percent of the NC's, forty percent of the PC's and sixty-five percent of the C's.

Item 2. Is the total amount of liquid in the five beakers equal to the amount in the original container? As in Section I, this item was also used to classify the subjects as to their knowledge of the concept of conservation of continuous quantity. None of the NC's gave correct responses, one hundred percent of the PC's answered correctly and one hundred percent of the C's gave correct answers.

Item 3. What would the amounts of liquid look like if they were returned to the original beakers? In this item, ninety-three percent of the NC's said that the amounts would be the same again if they were returned to the original containers and one hundred percent of the PC's and C's gave similar answers.

Based on the results of these two sections of the pretest, it is apparent that relatively few of the subjects were able to predict that the liquids would remain invariant when they were poured. Fewer than half of the NC's and PC's could predict this outcome and only sixty-five percent of the conservers could make accurate predictions. However, a surprisingly large proportion of the subjects in all three categories were able to give responses which indicated that they knew that if the liquids were returned to their original containers their amounts would be equal again.

Section III

This section contained only one item and was designed to ascertain whether the subjects realized that pouring a liquid into a different container did not affect the quality of that liquid.

Item 1. When asked if pouring would alter the quality of the liquid before them, sixty percent of the NC's said the quality would not change, sixty-two percent of the PC's and ninety-five percent of the C's gave similar answers.

Section IV

In this section of the pretest the subjects were presented with pictures of conservation problems (see Figures 1 to 8, Chapter III) and were required to say whether the quantities shown would remain invariant or not if poured into other containers. There were eight items in this section and consequently a total correct score of eight. The mean total score for the NC's was 2.1 while the mean scores for the PC's and C's were 4.5 and 7.0 respectively.

It is interesting to note some of the responses given by the subjects when asked to justify their answers for various items of the pretest. Non-conservers were often reluctant to commit themselves on the question of the identity of the liquid (section III) and frequently said that they "thought" it would be the same but that they weren't sure. Partial conservers were more sure of themselves and frequently said, "Well, I just know that it is the same." Conservers, however, were the most confident and tended to explain their answers by saying that they knew that it would be the same because pouring would not change the liquid.

The non-conservers and partial conservers who answered questions incorrectly when presented with the quantities poured into different

containers usually explained their responses in ways which showed that they centered upon either the height of the fluid in the container, the size of the container, or in the case of Section II, the number of containers. Conservers were usually able to explain their answers by referring to the compensatory nature of the relationships between height and width or merely by stating that if the quantities were the same to begin with, they would remain the same when they were poured.

II. RESULTS OF POSTTEST

The first posttest was administered immediately after the training session for the experimental group and after an equal interval of time in the case of the control group. The results of this test are given in Table II.

Since the items of the second posttest were identical to those of the pretest and since the results and percentage of subjects giving correct responses are given in Table II, the results of this posttest are not dealt with in detail as in the case of the pretest results. In general, it should be noted that the subjects who took part in the training sessions substantially increased their scores while the scores of the control subjects remained relatively unchanged. A comparison of Tables I and II shows the difference in the absolute scores and the percentages of subjects who gave correct responses.

Observation of the testing procedures revealed that while the control group tended to justify their responses in ways similar to

those used in the pretest, the experimental group was not more sophisticated in its explanations for conservation. These subjects usually told the examiner that they knew that the quantities would be the same after they were poured because they were the same to begin with, because pouring wouldn't change the quantity or because (assuming that the experimenter did not know any better) the quantities only looked as if they were different, but that they were really the same thing.

Since the only apparent differences between the two groups was the fact that the experimental group had participated in the training session while the control group had not, it was concluded that the difference in the scores of the two groups was a result of the training. The next question to be answered by the study was whether the subjects could retain what they had learned over a two to three week period and whether or not they could transfer this learning to a new situation using different materials. The answers to these questions were sought by means of the second posttest.

III. RESULTS OF POSTTEST II

The second posttest was administered to all the experimental subjects and the conservers after a two to three week interval had passed since the administration of the first posttest or an equivalent length of time in the case of the conservers. The results of this test are shown in Table III. As indicated by the table, the group of conservers achieved perfect scores on each item as did the

TABLE II

NUMBER AND PERCENT OF SUBJECTS IN THE EXPERIMENTAL AND CONTROL GROUPS GIVING CORRECT RESPONSES ON POSTTEST II

Section	Item	Description	Experimental NC	%	PC	%	Control NC	%	PC	%
I	1	Predicts equality before pouring	25	86	11	100	10	33	6	60
	2	Claims equality after pouring	25	86	11	100	2	6	5	50
	3	Predicts equality if re-turned to original con-tainers	28	96	11	100	25	82	9	90
II	1	Predicts equality before pouring	26	89	11	100	14	46	7	70
	2	Claims equality after pouring	27	92	11	100	3	10	5	50
	3	Predicts equality if re-turned to original con-tainers	29	100	11	100	25	82	10	100
III	1	Recognized the invariance of the quality of the liquid	28	96	11	100	19	62	8	80
IV	1	Predicts equality in the pictorial representations (items 1–8)	29		11		25		9	
	2		27		11		23		8	
	3		27		11		0		5	
	4		27		11		0		3	
	5		28		11		5		3	
	6		28		11		3		2	
	7		27		11		2		3	
	8		26		11		1		3	
		Mean for Section IV possible total 8	7.5		8.0		1.9		3.6	

NOTE: NC = Non-conservers (N = 29 experimental, 30 control)
PC = Partial conservers (N = 11 experimental, 10 control)

TABLE III

NUMBER OF EXPERIMENTAL AND CONSERVER SUBJECTS

GIVING CORRECT RESPONSES ON POSTTEST II

Section	Item	Description	Experimental NC	Experimental PC	Conserver
I	1	Predicts equality before pouring	28	11	20
	2	Claims equality after pouring	28	11	20
	3	Resists extiction suggestion	28	11	20
	4	Predicts equality if returned to original containers	28	11	20
II	1	Predicts equality before pouring	29	11	20
	2	Claims equality after pouring	29	11	20
	3	Predicts equality if returned to original containers	29	11	20
III	1	Predicts equality before pouring	29	11	20
	2	Claims equality after pouring	29	11	20
	3	Predicts equality if returned to original containers	29	11	20
IV	1	Predicts equality before pouring	29	11	20
	2	Claims equality after pouring	29	11	20
	3	Predicts equality if returned to original containers	29	11	20
V	1	Predicts equality before pouring	29	11	20
	2	Claims equality after pouring	29	11	20
	3	Predicts equality if returned to original containers	29	11	20

NOTE: NC = Non-conserver (N = 29)
PC = Partial conserver (N = 11)
C = Conserver (N = 20)

experimental partial conservers. All of the experimental non-conservers scored perfectly on items two to five and only one subject failed to score on item one. Thus, the results indicated that the subjects were able to retain the concept over the specified period of time and similarly that they were able to transfer the learning to a new situation using new materials.

The responses of the subjects in this posttest are particularly interesting and reveal the manner in which they thought during this testing situation. Nearly all the subjects could offer some explanation for their answers. Among the answers given were: "Pouring doesn't change it, it never changes." "It's all the same stuff and the kind of jar doesn't matter." "If it's the same before, it's always the same." "It's the same, it only looks different." "It never changes." "You didn't lose any so it's always the same." "It's the same, only it's skinnier."

With the exception of one subject of the experimental group who did not answer correctly for any item in the first section, no subject allowed the examiner to extinguish the conservation concept through the use of the extinction suggestion.

It is also interesting to note that the three experimental non-conservers who did not show any evidence of having acquired the concept when given the first posttest, gave correct answers for every item in the second posttest. The answers of one of these subjects in the first posttest revealed that she could tell the examiner that pouring

would not change the quantity and she predicted that the quantity would not change before she saw it poured, yet when confronted with the fluid in the two or more different sized containers, she answered that the amounts were unequal. This subject utilized these very same arguments in the second posttest for justifying her conservation responses. A similar result was observed in the case of a non-conserver who was classified as a partial conserver after the training session. That is, he too was able to give correct conservation responses to every item on the second posttest. These occurrances, coupled with the fact that each of these four subjects answered correctly despite a suggestion to the contrary and the fact that they were able to justify their answers would indicate that for these four subjects at least, the two to three week interval between tests was beneficial in that during that time, they further developed their understanding of the conservation concept.

IV. THE STATISTICAL ANALYSES OF THE DATA

The statistical analyses of the results of the study in terms of the research hypotheses is described below. Each hypothesis was tested by means of an application of McNemar's Test for Significance of Changes. The level of significance required for the rejection of an hypothesis was 0.05. The contingency tables and probabilities for each hypothesis are shown in Table IV.

Hypothesis 1

The number of non-conservers who change to conservers as a result of the treatment is not significant. Since there was a significant change, this hypothesis was rejected. ($X^2 = 21.04$, $p \leq 0.001$)

Hypothesis 2

The number of partial conservers who change to conservers as a result of the treatment is not significant. The number of subjects who changed was found to be significant, consequently, this hypothesis was rejected. ($X^2 = 9.99$, $p \leq 0.01$)

Hypothesis 3

The number of non-conservers who change to partial conservers as a result of the treatment is not significant. Since the change which took place was not significant, this hypothesis was not rejected. ($X^2 = 0.00$, $p \leq 0.001$)

Hypothesis 4

There is no significant change in the number of subjects in the non-conserver control group at the end of the experiment. The change which did occur was not significant, hence, this hypothesis was not rejected. ($X^2 = 3.2$, $p \leq 0.07$)

Hypothesis 5

There is no significant change in the number of subjects in the partial conserver control group at the end of the experiment. The results of the statistical test revealed that the number of subjects who changed their classification was not significant, thus, the

hypothesis was not rejected. ($X^2 = 2.25$, $p \leq 0.12$) It should also be noted that of the four subjects who changed, two of them became conservers, but the other two regressed to non-conservers. Applying McNemar's test to determine the significance of two out of eight subjects changing categories results in an even less significant amount of change.

Hypothesis 6

There is no significant change in the number of subjects in the conserver group at the end of the experiment. Since no significant change took place, this hypothesis was not rejected. ($X^2 = 0.00$, $p \leq 0.001$)

Hypothesis 7

The number of non-conservers reclassified as conservers after the treatment who, over a two to three week period, change from giving conservation responses is not significant. The results of the statistical test showed that no significant changes had occurred, hence, this hypothesis was not rejected. ($X^2 = 0.00$, $p \leq 0.001$)

Hypothesis 8

The number of partial conservers reclassified as conservers after the treatment who, over a two to three week period, change from giving conservation responses is not significant. Since no significant changes occurred, this hypothesis was not rejected. ($X^2 = 0.00$, $p \leq 0.001$)

TABLE IV

RESULTS OF THE STATISTICAL ANALYSIS OF THE HYPOTHESES

USING McNEMAR'S TEST FOR SIGNIFICANCE OF CHANGES

Hypothesis 1

	C	NC
NC	25	3
C	0	0

$p \leq .001$

Hypothesis 2

	C	PC
PC	11	0
C	0	0

$p \leq .01$

Hypothesis 3

	PC	NC
NC	1	3
PC	0	0

$p \leq .001$

Hypothesis 4

	Other	NC
NC	5	25
Other	0	0

$p \leq .07$

Hypothesis 5

	Other	PC
PC	4	6
Other	0	0

$p \leq .12$

Hypothesis 6

	Other	C
C	0	20
Other	0	0

$p \leq .001$

Hypothesis 7

	Other	NC
C	0	25
Other	0	0

$p \leq .001$

Hypothesis 8

	Other	C
C	0	11
Other	0	0

$p \leq .001$

V. SUMMARY OF FINDINGS

The findings of the study may be summarized as follows:

1. On the basis of the pretest, the sample was classified into three categories: non-conservers (N = 59), partial conservers (N = 21) and conservers (N = 20).

2. Subjects who failed to conserve usually explained their responses by referring to either the height of the level of the water or to the size or number of the containers. Subjects who were classified as conservers were usually able to explain that a difference in the size of containers and the resultant change in the height of the water level did not effect the quantity.

3. On the basis of the results of the first posttest administered after the training situation, twenty-five of the twenty-nine experimental non-conservers were reclassified as conservers and all eleven of the experimental partial conservers were similarly reclassified as conservers.

4. The results of the second posttest indicated that (with the exception of one subject who did not score on section one) all of the experimental non-conservers retained the learning they had acquired and transferred it to a new situation. Each of the eleven partial conservers in the experimental group achieved similar results.

5. A significant number of non-conservers acquired the concept of conservation of continuous quantity as a result of the treatment.

6. A significant number of partial conservers acquired a better

knowledge of the concept of conservation of continuous quantity due to the treatment.

7. An insignificant number of non-conservers changed to partial conservers as a result of the treatment.

8. An insignificant number of non-conservers in the control group acquired an understanding of the concept without benefit of training.

9. The number of partial conservers in the control group who acquired a better understanding of the concept without benefit of training was not found to be significant.

10. No significant change took place in the number of subjects originally classed as conservers over the period that the study was in progress.

11. The twenty subjects classed as conservers at the beginning of the study were all able to transfer their understanding of the concept to a new situation as provided in the second posttest.

12. All of the non-conservers who had taken part in the training sessions were able to transfer what they had learned to a new situation two to three weeks later.

13. All of the partial conservers who had taken part in the training sessions were also able to transfer their improved understanding of the concept of conservation of continuous quantity to a new situation two to three weeks later.

CHAPTER V

SUMMARY, CONCLUSIONS AND IMPLICATIONS

I. SUMMARY

The purpose of this study was to investigate the acquisition of the concept of conservation of continuous quantity and to attempt to develop the concept experimentally. Piaget's classical test for the conservation of continuous quantity was administered to one hundred grade one children ranging in age from 5.75 years to 7.00 years. The mean intelligence quotient of the sample was 104.46. Based on the results of the pretest, the sample was classified as to their knowledge of the conservation concept. The sample was found to consist of fifty-nine non-conservers, twenty-one partial conservers, and twenty conservers.

The partial and non-conservers were randomly assigned to experimental and control groups with the experimental subjects taking part in a training session while the control subjects received no training. All non-conservers and partial conservers were posttested immediately after the training session and two to three weeks later, the experimental subjects and the conserver subjects were given a posttest designed to ascertain how well they understood the conservation concept and whether they could transfer their knowledge of it to a new situation using different materials.

II. DISCUSSION OF THE FINDINGS

The Hypotheses

The results of the study in terms of the research hypotheses were as follows:

Hypotheses 1. The number of non-conservers who change to conservers as a result of the treatment was rejected since the analysis showed that twenty-five of the twenty-nine non-conservers did acquire an understanding of the concept as measured by Piaget's classical test of conservation. This finding supports the theory upon which the training experiences were based.

Hypothesis 2. The number of partial conservers who change to conservers as a result of the treatment is not significant. This hypothesis was also rejected since every one of the partial conservers was reclassified as a conserver after the training session. This finding adds further support to the theory used in the training.

It is interesting to note that while twenty-five of the twenty-nine non-conservers benefited from the training session, all of the eleven partial conservers were reclassified as conservers after the training. This was as expected since it is reasonable to assume that those subjects who came to the training session with a partial understanding of the concept would be more likely to benefit more from the training than subjects who showed no knowledge of the concept beforehand.

Hypothesis 3. The number of non-conservers who change to partial conservers as a result of the treatment is not significant. Only one of the twenty non-conservers changed to a partial conserver after the training, consequently, this hypothesis was not rejected. These results may be interpreted as a strong indication that the procedures used in the training were so effective that it was more probable that a subject would acquire a complete rather than a partial understanding of the concept.

Hypothesis 4. There is no significant change in the number of subjects in the non-conserver control group at the end of the experiment. Only five of the thirty non-conserver control subjects changed to partial conservers. Since this was not a significant change, the hypothesis was not rejected.

Hypothesis 5. There is no significant change in the number of subjects in the partial conserver control group at the end of the experiment. Four of the ten subjects in this group did change. This number was not significant, consequently, the hypothesis was not rejected. However, it should be noted that of the four who changed, two of the subjects changed to conservers while the other two regressed to non-conservers. Testing the significance of the possibility of two subjects changing out of a total of ten results in a Chi-square of 0.50 and a probability of between 0.50 and 0.30. In addition, since an interpretation of this kind implies a direction for the change, and a one tailed test, the above probabilities should be halved which still

results in a probability which is not significant.

The finding that the number of subjects in the control groups who changed classifications without benefit of training is not significant would seem to invalidate any argument that the subjects in the experimental group would have acquired the concept naturally within the time during which they participated in the experiment. While it is true that Piaget has stated that most children acquire the concept at approximately the ages of seven or eight and that the mean age of this sample was 6.15, the fact remains that Piaget's classical test of conservation indicated that fifty-nine percent of the sample did not have the concept prior to the beginning of the experiment and that nearly all of the subjects who were trained acquired the concept, while an insignificant number of the control group did not.

Hypothesis 6. There is no significant change in the number of subjects in the conserver group at the end of the experiment. All of the conservers scored perfectly on the second posttest, consequently, an insignificant number of subjects changed and the hypothesis was not rejected. This second posttest was administered to the conservers in an attempt to determine how stable their concept of conservation of continuous quantity was when it had developed naturally. The results indicated that when a subject has developed the concept naturally (as measured by Piaget's test) it is completely stable and is resistant to extinction.

Hypothesis 7. The number of non-conservers reclassified as

conservers after the treatment who, over a two to three week period, change from giving conservation responses is not significant. At the end of the training session twenty-five of the twenty-nine non-conservers were reclassified as conservers. The results of the second posttest indicated that all twenty-five of these subjects retained the concept during the intervening two to three weeks and could transfer it to a new situation using different materials. Consequently, this hypothesis was not rejected.

It should also be noted that of the four experimental non-conservers not accounted for above, one was reclassified as a partial conserver and the other three remained classified as non-conservers after the first posttest. However, when the second posttest was administered to these four subjects two to three weeks later, each one of them gave correct conservation responses for each item and were subsequently reclassified as conservers. The reasons for this delay in acquiring the concept despite the training may be explained as follows.

According to Piaget, partial conservers are in a state of transition between full, operational conservation and a complete lack of understanding of the concept. Consequently, they tend to vacillate between the two extremes and are prone to give conservation responses one time and non-conservation responses the next. This would help to explain why the subject who became a partial conserver gave some incorrect responses on the first posttest and all correct responses on the second posttest.

The reason for the discrepancies between responses in the case of the three non-conservers who later conserved is more difficult to explain. However, one possible explanation is suggested by the answers given by one of these subjects. During the first posttest, this subject predicted that the quantities would be conserved for both items of the test used for classification purposes and knew that the quantities would be the same if they were poured back into the original containers. Yet when confronted with the quantitites in the dissimilar containers, she gave non-conservation responses. Additional questioning revealed that the subject could tell the examiner that pouring would not change the amount of the quantities and that she could also explain why the water level rose in a tall, slim container and fell in a wide, shallow one. However, the subject apparently did not see any contradiction between these explanations which would account for the conservation of the quantities and her non-conservation responses. In Piagetian terms, it seemed as if the subject possessed all the requisite elements to explain conservation but could not combine them into an internalized system. The fact that this same subject used these same explanations to account for her conservation responses two to three weeks later would seem to support this interpretation of her previous responses.

If the reasons outlined above were valid for one subject, it is not unreasonable to assume that similar circumstances accounted for the variations in the responses of the other two non-conservers.

Hypothesis 8. The number of partial conservers reclassified as conservers after the treatment who over a two to three week period, change from giving conservation responses is not significant. Since all of the experimental partial conservers scored perfectly on the second posttest, this hypothesis was not rejected.

In summary, it may be stated that the results indicated that the training procedures were highly successful and that the concept once acquired lasted for at least a two to three week period, transferred to a new situation using different materials and was resistant to an attempt at extinction.

Other Results

The pretest and the first posttest included items designed to provide information regarding the subjects' understandings of the reversibility principle and information concerning their abilities to think about the problem in various modes of thought. The results of these findings are described below.

The first item in each of the first two sections of the pretest required the subject to predict whether the quantities would be conserved if they were poured into various containers. The results indicated that no more than half of the non-conservers and partial conservers were able to predict conservation and that only sixty-five percent of the conservers were able to predict correctly. Thus, it would seem that even for the conservers, it was difficult for the subjects in this sample to imagine accurately the result of pouring a quantity.

Once the quantities had been poured, the subjects were asked what they would look like if they were poured back into the original containers. The results for this question (item 3) were rather surprising. In section I of the pretest, eighty percent of the non-conservers, eighty-six percent of the partial conservers and one hundred percent of the conservers gave correct responses. In the section II of the pretest the percentages of correct responses for the three groups were ninety-three percent, one hundred percent and one hundred percent respectively. These results would seem to cast serious doubt upon the claims of some researchers that an understanding of the principle of reversibility (when defined as the knowledge that a return to the starting point finds the quantities unchanged) is sufficient for an understanding of the concept of conservation. Reversibility as it has been defined above may well be a prerequisite to the development of the understanding of the concept of conservation, but is apparently not sufficient in itself to permit an immediate grasp of the concept. In this connection it is interesting to note the distinction between the two elements of reversibility as discussed by McLaughlin (1963). His definition would seem to be more appropriate in view of the results reported above and those of other researchers concerning the principle of reversibility.

Bruner (1966) has suggested that one of the prerequisites for the understanding of the concept of conservation is what he has termed the understanding of the principle of identity. The subjects' knowledge

of this aspect was assessed in section III of the pretest and first posttest. In these sections the subjects were asked whether the quality of the fluid changed as a result of transformations. The results indicated that the non-conservers, partial conservers and conservers gave correct responses in the pretest in the following percentages: sixty percent, sixty-two percent and ninety-five percent respectively. The difference between the scores of the non-conservers and partial conservers as opposed to the conservers who already possessed the concept of conservation would indicate that there is some support for Bruner's claim, however, as in the case of the principle of reversibility, the presence of this understanding is not sufficient in itself to result in the acquisition of the concept of conservation as there were many subjects with an understanding of identity who could not conserve.

Additional support for this conclusion may be drawn from the fact that the experimental group of subject who substantially increased their knowledge of the conservation concept during the training session also improved their understanding concerning the principle of identity. The percentages of the groups who gave correct responses on this item increased from sixty percent for the non-conservers and sixty-two percent for the partial conservers prior to training, to ninety-six and one-half percent and one hundred percent for these same two groups.

The fourth sections of the pretest and first posttest were designed to measure the subject's abilities to conserve when the

problems were presented to them in pictorial form. The impetus for these sections of the design derived from Bruner's theory that a child's development of thought proceeded through three modes of representation: enactive, ikonic and symbolic. By presenting the conservation problem in the form of a picture, the subject had to think of the situation using an ikonic form of representation. At the same time the examiner requested the subject to state what he thought would happen when the quantities were poured. This called for a symbolic response by the subject.

The results of these sections of the tests revealed that prior to the training session the non-conservers and partial conservers achieved mean scores of 2.1 and 4.5 respectively, out of a possible score of 8. After the training session, these scores improved to 7.5 for the non-conservers and 8.0 for the partial conservers. The scores for the control group did not improve during the time the training sessions were in progress, rather they decreased slightly.

These results indicated that the conservers who already possessed the concept of conservation were better able to think ikonically and symbolically in these problems than were subjects who did not already possess the conservation concept. After having acquired the concept experimentally, however, the experimental subjects were also more adept at thinking about the problems in these modes.

Posttest II was designed to measure the subjects' abilities to retain the concept over a two to three week period and to determine whether or not they could transfer their knowledge of the concept

to a new situation despite an extinction suggestion. The results indicated that almost without exception, all of the experimental subjects were able to achieve perfect scores on the test. This would indicate that the training procedures resulted in the subjects' developing the concept to the extent that it could be applied to other situations and that the subject's knowledge of the concept could not be extinguished at least by the suggestion made in this study.

In Chapter I of this report reference was made to three questions which, it was hoped, could be answered with the data resulting from the study. The questions were: (1) What mental processes are involved in the development of the concept of conservation of continuous quantity? (2) Can these processes be satisfactorily explained by Piaget's theory? (3) Can these processes be developed in children earlier than is normally the case according to Piaget?

The results of the study provide support for the following answers to these questions. The training procedures were based on the theory that the mental processes involved in the acquisition of the concept were an identity operation by which the child would recognize that the quality of the quantity remained unchanged irrespective of the transformations, a logical multiplicative operation in which the child would be able to combine the relationships of height and width and understand how an alteration in one might be compensated for by an appropriate change in the other, and lastly, operational reversibility by which the child would realize that a return to the

starting point would find the quantities unchanged and at the same time the understanding that the effects of an operation may be compensated for by a reciprocal operation.

In addition to these cognitive operations, the training also included three procedural techniques; perceptual screening in which the subject's initial perceptions of the problem were hidden from him, a high degree of verbalization by the subject, and the blending of both of the above into a discovery method of teaching.

Since the training was highly successful, it is reasonable to assume that it must have included the necessary procedures and processes required for the development of the conservation concept. Hence, it was concluded that for this sample at least, the theory was proved to be valid. However, it was not possible to ascertain whether all three of the mental processes were crucial to the development of the concept or whether one or two of them may have been sufficient to achieve the desired results.

The second question related to how well Piaget's theory could be used to account for the above mentioned mental processes. An examination of Piaget's works reveals that he has mentioned each of these processes in some connection with the development of the concept of conservation. However, due to the rather ambiguous quality of Piaget's writings, it is difficult to determine whether his definitions for these processes are the same as the interpretations adopted by the present investigator. For instance, Piaget defines identity in

the following manner,

> There is one and only one element (the identity element) which, when added to any other element whatsoever, leaves that other element unchanged. (Flavell, 1963, p. 174)

If, in the case of the conservation of continuous quantity, one considers the quality of the fluid to be one element and any transformation as the identity element, then it may be seen that this interpretation may be analogous to Piaget's definition of identity as quoted above. That is, a transformation added to the quality of the fluid leaves the quality unchanged.

Piaget's theory concerning the multiplication of relations appears to apply directly to the present study. Piaget claims that it is not until the child reaches the level of concrete operations that he can logically combine two aspects of a problem together simultaneously. He has further claimed that this ability is necessary for the understanding of conservation.

Operational reversibility is also cited in Piaget's writings as a characteristic of conservation. Flavell (1963, p. 181) explains Piaget's meaning of reversibility as it applies to concrete thought (which according to Piaget, is when conservation occurs) as follows:

> Thus, the inverse or reversibility property of concrete operational structures assumes two different forms: <u>negation</u> in the case of classes and <u>reciprocity</u> in the case of relations.

This definition appears to agree with the theory propounded by McLaughlin (1963) that reversibility involves inversion and reciprocity.

In summary, it may be stated that Piaget's theory was found to be quite adequate in accounting for the processes upon which the training situations were based. Piaget was found to have dealt with each of the aspects in relation to the development of the concept of conservation in general, and mentioned each of the processes in connection with the stage of concrete operations, the stage at which he claims conservation occurs.

The third question related to whether or not these processes can be developed in children earlier than is normally the case according to Piaget. Piaget argues that a child cannot conserve until he has reached a certain level of cognitive maturity and that the appearance of the ability to conserve is an indication that the child has attained this level. In addition, he claims that the development of requisite mental abilities is dependent primarily upon equilibration and to some lesser degree on maturation, experience and social transmission.

Assuming that Piaget's classical test for the conservation of continuous quantity is both valid and reliable, then subjects who fail to show any indication of a knowledge of conservation as measured by this test, cannot, according to Piaget, possess the necessary cognitive abilities. Conversely, subjects who are able to conserve, as measured by the test, must possess these abilities. How, then, can one explain the reasons for the sudden acquisition of the concept by subjects who previously showed little or no understanding of it?

Two alternative explanations are suggested for the effect of the training procedures. (1) The experimental subjects did not possess the requisite abilities and these were developed during the training session. (2) The subjects already possessed the requisite abilities but were unskilled in their use and the training procedures taught them how to use the abilities. The first explanation does not seem to be tenable for a number of reasons. In the first place, existing research has indicated that it is extremely difficult to develop cognitive abilities in children if certain (as yet undefined) underlying cognitive processes are not already present. Secondly, the training procedures were designed to help the children use certain abilities which were implicitly assumed to be already in existence. Lastly, it is doubtful if anything as complex as a cognitive process could be developed in the short fifteen minute period of the training session. In summary, it is highly improbable that the first suggested explanation could be correct.

This leaves the second explanation to be considered. Support for its case may be found in Piaget's theory as he states that conservation is dependent upon the existence of certain cognitive abilities. Since the subjects acquired the concept, it follows that they already possessed the necessary abilities. In addition, the training procedures were essentially illustrative experiences and depended for their success upon the prior existence of the necessary cognitive structures in the subjects so that the latter could benefit from the training.

In conclusion, it would seem that the second explanation is the most appropriate in view of the results of the study. Such a conclusion has important ramifications in terms of Piaget's claims concerning the ages at which conservation occurs and the existence of the necessary cognitive abilities. In the face of a lack of evidence to the contrary, it is assumed that his sequence of stages for the development of the concept of conservation is correct. However, the results of this study offer evidence that the ages at which these stages occur are incorrect, and that the necessary cognitive abilities are present in children of approximately six to seven years of age but are latent.

The evidence of this study indicates that children of these ages are capable of acquiring the conservation concept. It is not unreasonable to assume that the children's natural environment has never presented them with a need to bring the requisite cognitive abilities to bear on a problem of this nature. While it is true that children do have numerous occasions to watch while milk and other fluids are poured and that they are often involved in selecting the greatest amount to drink from several containers, they are rarely presented with the problem of judging whether two amounts are equal if they are poured into different sizes of containers. Nor are they often faced with a situation in which they have to equate the amounts in containers of various sizes or shapes. The benefits of the training program in this study derived from the fact that for the first time,

children who had the necessary cognitive abilities were helped to discover how they must consider the crucial aspects of the conservation problems in order to reach a logical conclusion concerning the invariance of the quantities.

III. IMPLICATIONS

The results of this study give rise to a number of educational and psychological implications, some of which are listed below.

1. The fact that the subjects in the sample were able to acquire the concept of conservation of continuous quantity after being classed as non-conservers implies that they already possessed the requisite cognitive abilities and that consequently, Piaget's statements to the effect that non-conservers do not possess these mental abilities must be reconsidered.
2. The results of the study support the contention that the acquisition of certain concepts may be accelerated if the appropriate teaching techniques are employed.
3. It is also apparent that the ages at which Piaget claims that the development of the concept of conservation of continuous quantity occurs may be lowered as a result of training.
4. The use in the training situation of a subject who possessed a partial knowledge of the concept appeared to work very well in conjunction with the discovery approach to the problem, hence, it is suggested that this technique of giving such children an opportunity

to help other children learn certain concepts in a small group situation may be very beneficial.

5. The success of the discovery approach and the use of small group instruction implies that teachers might be well advised to adopt either or both of these approaches in the classroom.

6. Since it is recognized that concept formation is closely associated with experience and social transmission, children should be provided with numerous opportunities to engage in group situations which have been structured to foster the development of certain concepts. For instance, in reference to the concept of conservation of continuous quantity, children would probably benefit from opportunities to engage in activities which allowed them to pour liquids into various shapes and sizes of containers while their attention was drawn to how this affected the amount of the liquid in each case.

7. Since it may be argued that understanding of the concept of conservation is a necessary condition for all reasoning, and since Piaget has shown that the first conservation concept to appear involves continuous quantities, it would seem to be in the best interests of children if educators made a more concerted effort to develop conservation concepts in children as early as possible.

8. Rawson (1965) has found that conservation concepts are related to children's abilities in reading, consequently it may prove to be very profitable to teach children certain conservation concepts as part of a reading readiness program.

9. Lansing (1966) has stated that a child's representation of visual symbols in his art work is related to his conceptual growth and that a child's ability to think in terms of concrete operations (the stage when conservation appears) also has an influence on his art work. It might be, then, that instruction in conservation concepts could have beneficial effect on children's art work.

10. Sigel (1966, p. 83) has stated that

> Conservation is a relevant principle for social science: the fact that a person maintains an invariant role in the face of social transformations, for example, is relevant to political science.

He also claims that an understanding of conservation is one of the cognitive acquisitions necessary for understanding other social sciences, hence it would seem that by helping children to develop an understanding of conservation, teachers would also be helping them to understand the social sciences.

11. There is also research evidence which indicates that conservation is involved in the area of music. Pflederer's study (1964) indicated that children who could conserve performed better on certain musical tests. Thus it may be that by developing conservation concepts in children, teachers might also affect their pupils' performance in music.

12. Research by Almy (1966) indicated that children who were able to conserve at an early age were able to perform better on tests related to beginning reading and beginning arithmetic. This would suggest that the development of conservation concepts in children

as part of a readiness program might have beneficial effects on their initial progress in these subjects.

13. Since conservation concepts appear to be so closely connected with subject areas such as mathematics and science where pupils frequently measure length, area, volume, mass and weight, it would seem logical to expect that efforts to develop the understanding of conservation in children would affect the latter's achievements in these two subject areas.

14. If the concept of conservation can be applied to such things as the sentence patterns in the English language, then it is not unreasonable to assume that the development of conservation concepts in children might also affect their abilities in the area of the language arts.

15. If the exact relationship between conservation concepts and pupils' abilities in the various subject areas can be determined with more precision, this information should contribute significantly to our knowledge of how to teach these subjects. Knowledge of such relationships might also suggest why children lacking certain cognitive abilities perform poorly in some subjects. Such an awareness should lead to the development of remedial programs designed to help pupil's acquire the missing cognitive skills.

16. This study also has relevance to the field of teacher education in that it points up the importance of using teaching techniques which are founded on sound psychological bases. Unless prospective teachers are exposed to courses in developmental child psychology and

shown how to use the knowledge they acquire about children's thought processes, we can expect little in the way of advances in better teaching techniques eminating from the classroom.

IV. SUGGESTION FOR FURTHER RESEARCH

This study has given rise to a number of questions which might profitably be explored by researchers. Some of these questions are presented below.

1. What are the exact procedures which have the most effect on the acquisition of the concept of conservation of continuous quantity?
2. Does training in one area of the conservation concept transfer to other areas? For instance, would the training described in this study affect a subject's ability to conserve quantities such as mass or weight?
3. What is the exact relationship between the ability to conserve and performance on mental abilities tests?
4. Additional research should be conducted to determine the relationship between pupils' understandings of the concept of conservation and their performance in the various subject areas.
5. More time should be devoted to developing programs of studies (for specific subject areas) which are based on sound psychological principles.
6. Educational researchers might profitable explore the question of whether teachers who understand children's cognitive thought processes really apply this knowledge in the classroom and if not, why not.

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APPENDIX

DATA TABULATION

Pretest ______ Posttest I ______

Hazeldean ____ Date ____________ I. D. No. ____________

Goldbar ____ Room ____________ IQ ____________

CA ____________

Group ____________ Classification C PC NC

SUBJECT ________________________

I. a) predicts conservation yes ____ no ____
b) observes and conserves yes ____ no ____ really more? yes/no

why? ________________________

c) same if poured back? yes ____ no____

why? ________________________

II. a) predicts and conserves yes ____ no ____
b) observes and conserves yes ____ no ____ really more? yes/no

why? ________________________

c) same if poured back? yes ____ no ____

III. Same drink? yes ____ no ____

why? ________________________

IV.

CARD	C	NC	REASONS
1			
2			
3			
4			
5			
6			
7			
8			

Comments:

DATA TABULATION

Posttest II

Hazeldean ____ Date ____________ I. D. No. ___________

Goldbar ____ Room ____________ IQ ________________

CA ________________

Group ____________ Classification C PC NC

SUBJECT ______________________________

I. a) predicts conservation yes ____ no ____

b) observes and conserves yes ____ no ____

c) resists extinction yes ____ no ____

d) same if poured back? yes ____ no ____

II. a) yes ____ no ____

b) yes ____ no ____

c) yes ____ no ____

III. a) yes ____ no ____

b) yes ____ no ____

c) yes ____ no ____

IV. a) yes ____ no ____

b) yes ____ no ____

c) yes ____ no ____

V. a) yes ____ no ____

b) yes ____ no ____

c) yes ____ no ____